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THE MAMMALS OF BIG BEND RANCH STATE PARK, TEXAS

FRANKLIN D. YANCEY, II

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Museum and Department of Biological Sciences,
Texas Tech University

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CONTENTS

INTRODUCTION 1
DESCRIPTION OF BIG BEND RANCH STATE PARK 3
Location 3
Human History 3
Climate 6
Physiography 6
Geology 9
Soils 10
Vegetation 10
MATERIALS AND METHODS 15
Data Acquisition 15
Data Analysis 16
RESULTS OF FIELD WORK 19
CHECKLIST OF SPECIES 23
FAUNAL ANALYSIS 27
Species Diversity and Similarity 27
Species Composition 27
KEY TO THE SPECIES 33
ACCOUNTS OF SPECIES 43
Native Species 43
Nondomestic Introduced Species 172
Domestic Species 173
Species of Postulated Occurrence 175
Extirpated Species 179
CONCLUSIONS AND RECOMMENDATIONS 181
ACKNOWLEDGMENTS 185
LITERATURE CITED 187
APPENDIX I. DATABASE FOR ENTRY OF FIELD DATA 203
APPENDIX II. GAZETTEER OF LOCALITIES SAMPLED 205

INTRODUCTION

With an area of approximately 1100 km^2, Big Bend Ranch State Park (hereafter, BBRSP) is one of the largest state-managed land areas in North America. The park, which is under the jurisdiction of the Texas Parks and Wildlife Department (TPWD), is located in the Trans-Pecos Region of Texas in Brewster and Presidio counties (Carrico, 1994).

Texas in general, because of its large size and a geographic location where four major physiographic subdivisions of North America merge, has a mammalian diversity that is exceptionally high (Schmidly, 1983). As a result, the mammals of the state have been the focal point of several major faunal studies. Bailey (1905), Davis (1960; 1966; 1974), and Davis and Schmidly (1994) provide general assessments of the mammalian fauna of the state. Regional studies, such as those by Schmidly (1983) for East Texas, Goetze (1995) for the Edwards Plateau of central Texas, Choate (1991) for the Llano Estacado of West Texas, Jones et al. (1988) for the northern Panhandle, and Dalquest and Horner (1984) for the north-central part of the state, added significantly to our understanding of Texas mammals.

Mammals from the Trans-Pecos Region of Texas also have received considerable attention. Initially, parts of the region were covered in Mearns' (1907) survey of mammals along the Mexican border. Later, based primarily on data from specimens in collections, Schmidly (1977*a*) assembled a synopsis of the mammals of the Trans-Pecos Region. Moreover, mammals from specific sites within the Trans-Pecos have been investigated in detail. These places include Guadalupe Mountains National Park (Davis, 1940; Genoways et al., 1979; Cornely et al., 1981) the Sierra Vieja (Blair and Miller, 1949), the Davis Mountains (Blair, 1940), and Big Bend National Park (Borell and Bryant, 1942; Easterla, 1973; Jones et al., 1993). In addition, the mammals of adjacent areas in Mexico have been studied in detail (Baker, 1956; Anderson, 1972). However, the area that is now BBRSP has received little attention. LoBello (1976) and Scudday (1976*a*; 1976*b*; 1976*c*) conducted short-term studies of the vertebrate fauna of selected sections of the area. These works included superficial surveys of the mammals in those sections, but a comprehensive, detailed analysis of the mammalian fauna of BBRSP is nonexistent.

The purpose of this research was three-fold. The first objective was to assess the diversity of mammals in BBRSP. By determining the kinds of mammals that occur in the park, opportunities are provided for various studies involving other aspects of mammalian biology. Wilson (1992:314) states, "As biodiversity surveys proceed at the several levels, the knowledge gathered becomes an ever more powerful magnet for other kinds of science."

The next goal was to determine the distribution of the various mammals within BBRSP. Mapping the structure of the mammals in the park is a key element in estimating the conditions under which each species lives. Also, patterns of mammalian distrubution, when linked with other biological and physical elements of the park, should prove instrumental in assessing the effectiveness of the park as a reserve (Wilson, 1992). This information will be of value regarding future consideration of conservation and management issues.

The final purpose of this study was to consolidate data on the natural history and ecology of the mammals of BBRSP. According to Schmidly (1977*a*), very little is known about various aspects of the life history of several species of mammals in the area. In addition to providing information to the overall understanding of the mammals of BBRSP, these data will be valuable when exploring potential long-term ecological studies, as well as designing management and interpretive programs for the park.

DESCRIPTION OF BIG BEND RANCH STATE PARK

Location

Big Bend Ranch State Park lies within the Trans-Pecos region of the extreme western part of Texas. This area is situated in the north-east corner of the Chihuahuan Desert. The park is positioned just north of the Mexican state of Chihuahua, from which it is separated by the Rio Grande. Big Bend National Park and the town of Lajitas occur to the east, and the city of Presidio is found to the west. The major portion of BBRSP is situated in the southeast corner of Presidio County, whereas a small part of the park occurs in the southwest corner of Brewster County (Fig. 1). The total area of the park is approximately 1100 km^2 (Alloway, 1995; Tucci, 1995).

Human History

More than 250 archeological sites throughout BBRSP provide information regarding the lives of the early human inhabitants of the area. The first humans arrived in the area between 8000-12,000 years before present (Wauer, 1992; Carrico, 1994; Sansom, 1995). For centuries, these people subsisted by hunting game and gathering the seeds, fruits, and roots of native plants. Later, with the introduction of corn, beans, and squash, agriculture evolved along the Rio Grande (Maxwell, 1994; Sansom, 1995). Gradually, the life styles of the hunter-gatherers and the agriculturists merged. The human inhabitants of the area exhibited this mixed-culture strategy when the Spaniard Cabeza de Vaca, the first European to visit the Big Bend, arrived in 1535 (Saunders, 1976*a*; 1976*b*; 1976*c*; 1976*d*; Wauer, 1992; Maxwell, 1994; Sansom, 1995).

Significant colonizations of the area in the Seventeenth and Eighteenth centuries reached no further north than the Rio Grande. For almost three centuries following its discovery by Europeans, the Big Bend region was dominated by hostile Indians, first by the Apaches, then by the Comanches. Then, in the mid-1800s, Texas was annexed by the United States and an important trade route linking Chihuahua, Mexico with Missouri was discovered. Part of this route, which later became known as the Chihuahua Trail, followed Alamito Creek through what is now BBRSP (Saunders, 1976*a*; 1976*b*; 1976*c*; 1976*d*).

In response to the development of the Chihuahua Trail, an early settler named Ben Leaton opened a trading post near where Alamito Creek empties into the Rio Grande. The trading post subsequently was called Fort Leaton and became the outpost of civilization in the Big Bend area. American interests in the region grew, which prompted an effort to subdue activities of the hostile Comanches. Shortly after the Civil War, those efforts were successful and the area opened up to settlement (Wauer, 1992; Maxwell, 1994).

With an increase in colonization in the area, many Americans saw the Big Bend as a potential for economic success. Ranching was the dominant commercial endeavor of the early settlers. Milton Favor was a successful pioneer rancher, having founded four large longhorn cattle and sheep ranches just north of BBRSP (Saunders, 1976*a*; 1976*b*; 1976*c*; 1976*d*). The first to ranch within what is now BBRSP was Andres Madrid, who developed a sheep ranch at the east end of the park in the 1870s (Anonymous, 1992).

In addition to ranching, early settlers profited from mining activities. In 1882, silver was discovered in Shafter, a small town near the northwest portion of BBRSP. Approximately 20 million dollars in silver was acquired from the mines of Shafter during about 40 years of operation. Also, cinnabar, the ore from which mercury is extracted, was mined in the region. Nearly 80 years of mining cinnabar in the Big Bend yielded approximately 25 percent of the mercury produced in the United States (Saunders, 1976*a*; 1976*b*; 1976*c*; 1976*d*). One of the major mercury mines, the Whitroy Mine, lies within present day BBRSP.

Although the products of mining activities were important commodities, land use in what was to be BBRSP was still dominated by ranching well into the Twentieth Century. Around 1910, the Bogel brothers acquired small sheep outfits and began assembling Big

Figure 1. Geographic position of Big Bend Ranch State Park, Texas.

Bend Ranch. However, in the 1930s, their business went bankrupt when the area was struck by a severe drought. Soon after, the Fowlkes brothers acquired the Bogel property, as well as other holdings, and assembled a 300,000 acre sheep ranch (Saunders, 1976*a*; 1976*b*; 1976*c*; 1976*d*; Alloway, 1995). But in 1958, following a seven-year drought, they were forced to sell the ranch to the Big Bend Ranch Corporation (Saunders, 1976*a*; 1976*b*; 1976*c*; 1976*d*; Carrico, 1994). The property was sold to Robert Anderson in the 1950s, and subsequently was developed into the 320,000 acre Diamond A Cattle Company (Saunders, 1976*a*; 1976*b*; 1976*c*; 1976*d*).

The land remained in Anderson's possession until 1988, when TPWD purchased it, along with holdings owned by Walter Mischer, for 8.8 million dollars (Saunders, 1976*a*; 1976*b*; 1976*c*; 1976*d*; Anonymous,

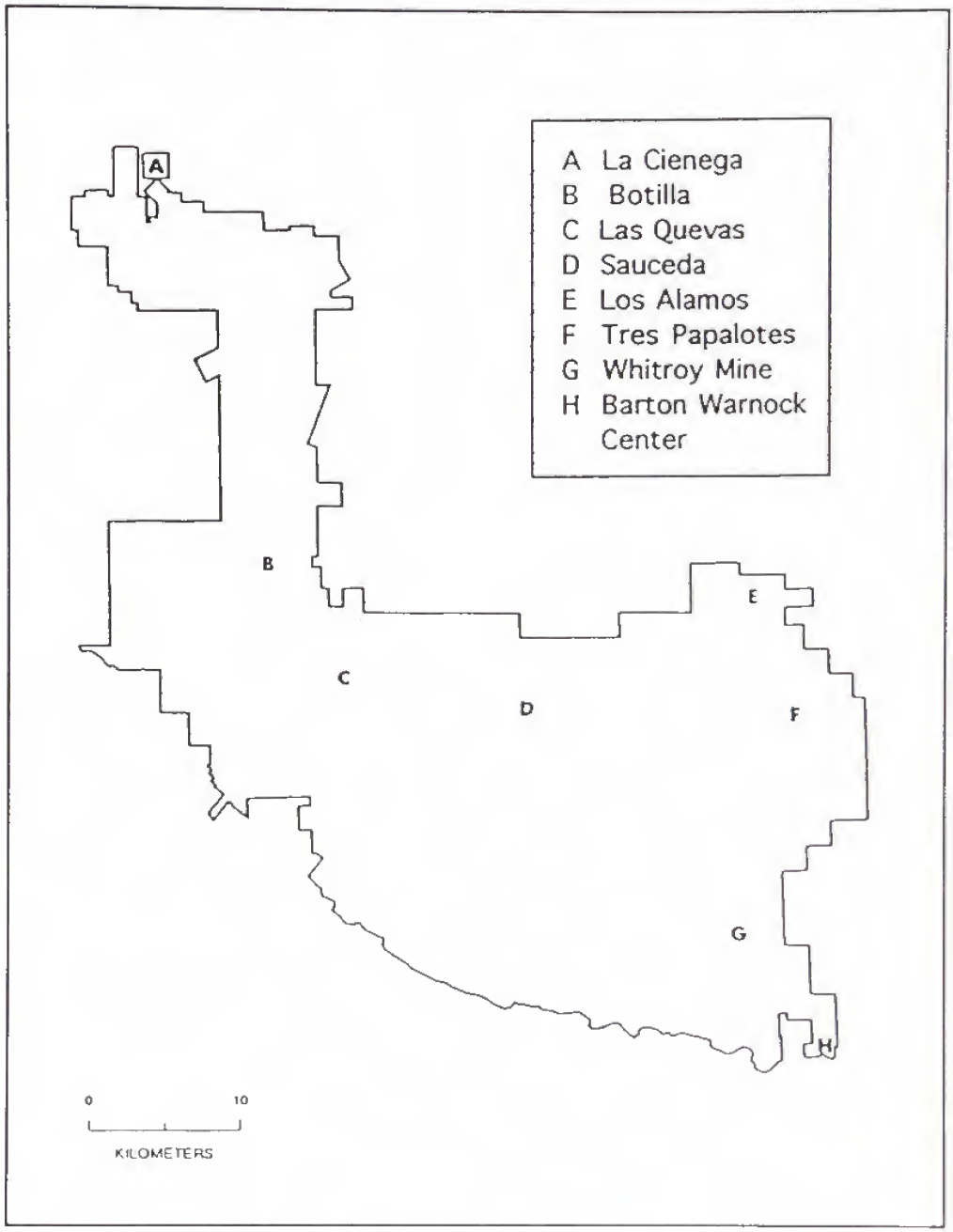

Figure 2. Locations of various sites mentioned in the text.

1992; Carrico, 1994; Alloway, 1995). Originally, TPWD designated the property as Big Bend Ranch State Natural Area. In 1995, the name was changed to Big Bend Ranch State Park (Anonymous, 1995*a*). At present, BBRSP accounts for over half the state park lands in Texas (Alloway, 1995).

Currently, BBRSP is still in the developmental stages. There are no paved roads in the park, and most visitor accommodations are primitive at best. Fourteen primitive campsites and four marked hiking trails are in existence, but much of the park is closed to the public. Most visitor activity is centered on areas along the Rio Grande or near the park headquarters at Sauceda Ranch. The current structure of the park, along with locations of places mentioned in this report, are depicted in Figure 2. These place names are defined in Table 1.

Table 1. List and description of some place names mentioned in the text.

Place	Description
Barton Warnock Environmental Education Center	Park visitor information and interpretive center located in Lajitas
Botilla	Vacated ranch often used as a research facility
Fort Leaton	State historical park and visitor information center
La Cienega	Vacated ranch currently used as a research facility
Las Cuevas	Area of impressive tuff formations with considerable archeological significance
Los Alamos	Vacated ranch sometimes used as a research facility
Sauceda	Park headquarters with visitor and research facilities
Tres Papalotes	Former ranch and proposed site of research center
Whitroy Mine	Vacated mercury mine at southeast end of park

Although visitation is relatively low at present, public tours and interpretive programs administered by both park personnel and private vendors are popular. Research opportunities in the fields of biology, geology, and archeology attract a variety of scientists. Also, in an attempt to lure tourists with a ranching interest, a herd of 100 to 150 longhorn cattle is maintained at the park. The policy of grazing cattle on a state park is a topic of considerable debate between environmentalists and those associated with the ranching community.

In an effort to increase the quantity of visitors, as well as the quality of their stay, TPWD has developed an operational plan for future improvements of BBRSP. Some of these actions are as follows: expand public use of the Rio Grande Corridor, Fresno Canyon, the Bofecillos Mountains, and the Solitario; renovate existing facilities, especially at Sauceda; improve existing roads and open new roads; open approximately 70 additional miles of hiking trails; increase interpretive programs, install wayside exhibits; and increase visitor safety by developing search-and-rescue, emergency operations, and law enforcement plans (Carrico, 1994).

Climate

The climate of the BBRSP area is characterized as semiarid to arid (Hanselka, 1976*a*; 1976*b*; Schmidly, 1977*a*), with mean annual temperatures of about 21°C (Dietrich, 1965). The winter months are dry and mild, although minimum temperatures frequently fall below freezing. Summers are hot, with mean daily maximum temperatures often over 40°C (Hanselka, 1976*a*; 1976*b*). Moderate to strong winds are common throughout the year.

The amount of precipitation in the area is low, with an annual average rainfall of about 28 cm. Most precipitation is the result of occasional convective thunderstorms, usually occurring towards the end of summer (Hanselka, 1976*a*; 1976*b*). However, infrequent winter snowfalls also may contribute to the annual level of precipitation. Short-term droughts are common throughout the Trans-Pecos region, whereas extended droughts occur about every 10 to 15 years (Schmidly, 1977*a*). During the period of this study, the area was in the midst of a six-year drought (Anonymous, 1996). The total amount of precipitation in 1994 (recorded at Lajitas) was only about 15 cm (Anonymous, 1995*b*); that recorded in 1995 (recorded at Sauceda) was about 21 cm. Climatological data taken at Presidio over a 30 year period are summarized in Table 2.

Physiography

The physiography of BBRSP is highly variable. The terrain consists of mountains, lowlands, arroyos, and deep canyons. With over 100 streams, springs, and seeps scattered throughout the park, the watershed is unique and extensive. In general, the park can be divided into six physiographic zones. They are: the Cienega Mountains, Alamito Creek and Terneros Creek lowlands, the Bofecillos Mountains, the Rio Grande Corridor, the Solitario, and Fresno Canyon-Contrabando lowlands (Carrico, 1994). The locations in the park that each zone occupies is illustrated in Figure 3.

The Cienega Mountains region of BBRSP consists of the southern slope of Cienega Mountain and its surrounding lowlands. The area technically is in the foothills of the Chinati Mountains, a fairly large moun-

tain formation to the west. The highest point in this zone is at the summit of Cienega Mountain, which is 1590 m in elevation. This peak lies outside of the northern boundary of the park. Inside the park, the highest elevation in this zone is approximately 1500 m on the southern slope of Cienega Mountain. The remainder of the zone is relatively level or gently sloped, with an average elevation of about 1200 m.

The major hydrologic feature of this area is Cienega Creek. This is a small, permanent stream that flows north to south through the western end of the zone. Eventually, the creek empties into Alamito Creek. Other sources of water in the area include Chupedero and Cat springs, which are small, permanent seeps.

The Alamitos Creek-Terneros Creek lowlands zone consists mostly of relatively level bottomlands. These flats typically are about 1000 m in elevation. The exceptions are Cerro Redondo and the Black Hills. Cerro Redondo is a small, round, hill-like formation 1129 m in elevation, which lies just north of Terneros Creek. The Black Hills is a group of small hills that occurs about midway between Terneros Creek and Alamito Creek. This formation has a peak elevation of 1109 m.

The major source of water in this zone is Alamito Creek. It is a relatively large, permanent creek that drains into the Rio Grande. Terneros Creek, on the other hand, is dry the majority of the time, flowing only following heavy rains. It too flows into the Rio Grande between Presidio and Redford. Alamo Seco and Black Hills creeks also are ephemeral watersheds in the region.

The Bofecillos Mountains region is the largest physiographic zone in BBRSP. It is characterized by irregular arrays of mountains and mesas interspersed with spectacular canyons. Elevations range from 1565 m at the peak of Oso Mountain, the highest point in the park, to less than 1000 m at the bottom of some of the deeper canyons.

Sources of water are abundant in the Bofecillos Mountains. Several natural seeps and springs of two types occur throughout the area. Primary springs are springs that are produced from ground water that has been discharged from bedrock aquifers present in underlying volcanic and sedimentary rock. Secondary springs are those that form in the bottom of arroyos in response to water flowing underground that is forced to the surface by impermeable strata. These types of springs usually are in arroyos below primary springs (Deal, 1976*a*).

Table 2. Climatological data for the Big Bend Ranch State Park area. Figures reflect weather conditions monitored at Presidio, Texas from 1961 to 1990.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Temperature (°C):													
mean	10.6	13.4	17.8	22.6	26.7	30.3	30.7	29.6	27.0	21.9	15.5	11.3	21.4
maximum	13.2	16.2	20.9	25.6	29.1	33.9	33.6	31.5	29.5	24.1	19.1	14.1	22.4
minimum	7.9	10.2	15.2	18.9	24.0	28.4	27.8	27.2	23.8	18.3	12.2	9.4	20.3
High Temperature (°C):													
mean	20.2	23.8	28.6	33.1	36.7	39.2	38.6	37.4	35.0	30.9	25.2	20.8	30.7
maximum	24.1	28.1	32.1	35.8	39.5	42.4	41.3	41.2	37.8	34.9	28.7	24.9	31.8
minimum	16.4	20.3	25.0	29.6	32.7	36.4	34.9	34.4	30.9	27.2	21.1	17.4	29.6
Low Temperature (°C):													
mean	0.9	3.0	7.0	11.9	16.7	21.4	22.7	21.7	18.9	12.8	5.8	1.7	12.1
maximum	4.6	5.3	10.6	15.3	19.0	25.4	26.1	23.4	21.4	15.7	9.3	5.8	13.7
minimum	-2.5	-0.8	3.6	7.9	14.1	19.2	20.1	19.6	16.0	8.8	1.8	-1.3	10.7
Total Precipitation (cm):													
mean	0.8	0.9	0.4	0.9	1.5	4.2	4.3	4.8	5.0	2.6	1.0	1.1	27.5
maximum	3.0	6.6	3.6	8.8	4.5	9.6	10.8	13.3	16.8	12.4	5.1	8.8	46.4
minimum	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.3	0.9	0.0	0.0	0.0	12.2

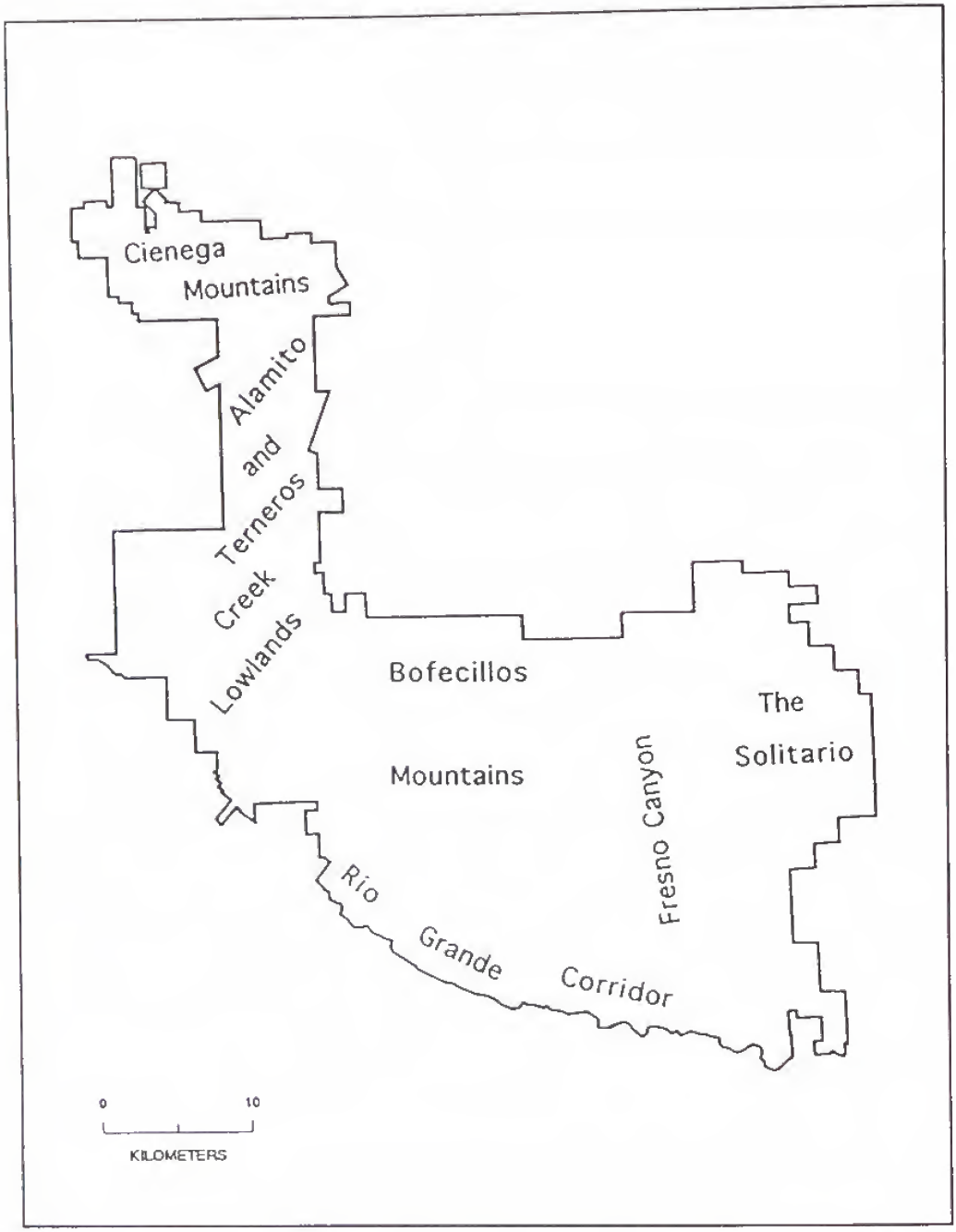

Figure 3. General areas of the six physiographic zones that occur at Big Bend Ranch State Park.

Two primary springs in the eastern part of the Bofecillos are major aquifers in the area. These are Chilcote or "Smith House Springs," and Ojo Mexicana. These water sources feed Mexicana Falls above Arroyo Segundo, which eventually feeds Fresno Creek. Additional primary springs in the area supply Madrid Falls above Chorro Canyon (Deal, 1976*a*). Other important springs in the Bofecillos include Palo Amarillo, Botilla, Rancherias, Aqua Adentro, and Ojito Adentro.

Water from the southern Bofecillos is drained by seven impressive canyons: Madera, Panther, Rancherias, Tapado, Las Burras, Auras, and Bofecillos canyons (Deal, 1976*a*; Smith 1976*a*). Water flowing

through each of these canyons form tributaries of the Rio Grande. The northern part of the Bofecillos Mountains is drained by northward flowing tributaries to Terneros Creek (Deal, 1976*a*).

The Solitario is a circular mountain and basin feature approximately 13 km in diameter. The outer rim consists of limestone mountains with elevations ranging from about 1300 to 1550 m. The central basin is mostly lowland flats with occasional resistant ridges comparable in elevation to the surrounding mountains. Elevations in the interior extend from 1250 to 1350 m (Deal, 1976*b*; Smith, 1976*b*).

Permanent sources of water are lacking in the Solitario and flowing water is rare. However, following infrequent torrential rains, the basin is drained by four major streams or "shutups." They are: the Lefthand Shutup, which drains the northern basin near Tres Papalotes and eventually flows into Terlingua Creek to the east; the Lower Shutup, which drains the southern interior and ultimately reaches Fresno Creek; and the Righthand and Los Portales shutups, which drain the western basin, also feeding Fresno Creek (Deal, 1976*b*).

Fresno Canyon is a deep canyon cut by Fresno Creek, a southward-flowing tributary of the Rio Grande (Smith, 1976*c*). It separates the Bofecillos Mountains to the west from the Solitario to the east. Elevations in this zone range from approximately 1160 m in the floor of the canyon, to greater than 1600 m at its northwestern edge near the outer rim of the Solitario. The area is drained by Fresno Creek, which receives flow from Arroyo Primero and Arroyo Segundo of the Bofecillos Mountains, and occasionally from the Lower, Righthand, and Portales shutups of the Solitario (Deal, 1976*c*).

The Rio Grande Corridor consists of the region along the southern boundary of BBRSP formed by the Rio Grande. To the east, the corridor consists of relatively flat lowlands with elevations as low as about 700 m near Lajitas. Further west, the river cuts through deep canyons with sheer cliffs greater than 400 m in height. Elevations exceed 1500 m in some of the more mountainous areas along the river. These areas actually are extensions of the Bofecillos Mountains to the north. Nearly all of the water from BBRSP eventually drains into the Rio Grande (Deal, 1976*d*).

Geology

The oldest and most complex rocks in the Big Bend area are those of Paleozoic age (550 to 300 million years ago). Following the deposition of these rocks, a series of orogenic events in the late Pennsylvanian-early Permian time resulted in the formation of the Ouachita fold belt. This continuous band of folding probably extended across a considerable portion of the southern United States and into North Africa, to which North America was in contact with at the time. Continental drift eventually separated the North American fold belts from those of North Africa. This mountain-building period lasted up to 100 million years, during which considerable erosion occurred simultaneously with active orogeny. Another 50 million years of erosion took place following the termination of mountain building. This extensive erosion resulted in the formation of low, flat surfaces atop the complexly folded and faulted Paleozoic sediments (Deal, 1976*b*).

Following the completion of the Ouachita Orogeny, invasive Cretaceous seas deposited about 1200 m of thick, flat, limestone beds. Toward the late Cretaceous and early Tertiary, a second orogenic event, the Laramide Orogeny, resulted in the formation of the American Cordillera. These folds are at nearly right angles to the Ouachita folds. As the result of continued orogeny, folding and faulting of the already complex Paleozoic rocks continued. Following the Laramide Orogeny, a series of igneous intrusions occurred and then volcanic eruptions covered the older limestone with ash and lava (Deal, 1976*b*).

Formation of the Solitario began in the early to middle Tertiary (45 to 20 million years ago). A lacolithic intrusion of magma into the Cretaceous limestone that failed to reach the surface caused the area to bulge. This activity formed the Solitario dome. Subsequent erosion removed the Cretaceous rocks from the crest of the dome. This activity resulted in the formation of a bowl-shaped structure with an outer rim of Cretaceous limestone and an interior basin of Paleozoic sedimentary rocks (Deal, 1976*b*; Maxwell, 1994).

While the Solitario was being formed by erosion, a large volcano up to 30 km in diameter and 1000 m in height, was forming the Bofecillos Mountains. This volcano was formed atop the same complicated sequence

of Paleozoic and Cenozoic sedimentary rocks. Following a series of eruptions, the volcano remained as a gently sloping cone consisting of alternating layers of solid lava, volcanic ash, and water-deposited sedimentary rocks. With time, eruptions became fewer and milder and several domed uplifts were formed when igneous intrusions failed to reach the surface. Subsequently, vertical displacements along several faults, followed by erosion by the Rio Grande and its tributaries, dissected the volcano and formed the mosaic of mesas and canyons present today. The formation of the Bofecillos volcano was associated with other eruptive activity in the Big Bend area, including that responsible for the formation of the Cienega Mountains (Deal, 1976*a*).

Soils

Soil types are highly variable throughout BBRSP. Soils in the mountainous areas usually are shallow and associated with igneous rocks and boulders. They are the result of weathering and erosion on moderately steep to steep slopes (Hanselka, 1976*c*). In Fresno Canyon, soils of this type are referred to as Brewster stony loams (Hanselka, 1976*b*). Many lower areas below the higher peaks and mesas have become filled with shallow, gravelly loams with stones up to 7.5 cm in diameter. Soils in shallow draws often are relatively deep and rich, with good soil-air-moisture-plant relationships (Hanselka, 1976*a*; 1976*c*). In the Fresno Canyon area, these soils are classified in the mimbres loam unit (Hanselka, 1976*b*). In addition, cobbly, gravelly, sandy, silty, and clay loams occur in various regions throughout the park (Hanselka, 1976*b*; 1976*c*). Rio Grande floodplane deposits include fine to medium sand, silt, and mud. Sidestreams typically deposit sand or sandy gravel (Deal, 1976*d*).

Vegetation

Essentially all of the plants that occur in BBRSP belong to the northern Chihuahuan Desert flora (Powell, 1988). The vegetation of BBRSP can be grouped into four major habitat types: desert scrub, desert grassland, riparian, and juniper roughland. Although there is considerable overlap in the species of plants that occur in these habitats, each is defined by a dominant vegetation.

Currently, Chihuahuan Desert scrub (Fig. 4) probably is the most widespread and abundant habitat type in the park, having replaced much of the former desert grassland (Powell, 1988). This plant community usually is dominated by creosote-bush (*Larrea tridentata*), but may consist of a mosaic of a number of scrub species such as ocotillo (*Fouquieria splendens*), mesquite (*Prosopis glandulosa*), acacia (*Acacia* sp.), mariola

Figure 4. Typical Chihuahuan Desert scrub habitat of Big Bend Ranch State Park.

(*Parthenium incanum*), lechuguilla (*Agave lechuguilla*), candelilla (*Euphorbia antisyphilitica*), leatherstem (*Jatropha dioica*), four-wing saltbush (*Atriplex canescens*), allthorn (*Koeberlinia spinosa*), agarito (*Berberis trifoliolata*), as well as several species of cacti (*Echinocereus* sp., *Mammillaria* sp., *Opuntia* sp.)

Historically, desert grassland (Fig. 5) was the dominant plant community throughout the area. Although a considerable portion of this habitat type has been modified by about 150 years of grazing by domestic livestock, a substantial amount of grassland remains in the park (Schmidly, 1977*a*; Powell, 1988). Species of grasses that dominate desert grassland include blue grama (*Bouteloua gracilis*), side-oats grama (*B. curtipendula*), chino grama (*B. ramosa*), black grama (*B. eriopoda*), tobosa grass (*Hilaria mutica*), needlegrass (*Stipa* sp.), and bluestem (*Bothriochloa* sp.). Other plants frequently associated with these grassland habitats include sotol (*Dasylirion* sp.), prickly pear cactus (*Opuntia* sp.), and yucca (*Yucca* sp.), to name a few.

Water-associated or riparian habitats are scattered throughout the park wherever seeps, springs, streams, or rivers exist. Although only a small fraction of the habitats of the park can be described as riparian, this habitat may be the most significant in terms of biological diversity. The riparian flora of the interior of the park (Fig. 6) primarily consists of cottonwoods (*Populus* sp.), willows (*Salix* sp.), and seepwillows (*Baccharis* sp.), but often includes other plants such as catclaw acacia (*Acacia berlandieri*), common buttonbush (*Cephalanthus occidentalis*), walnut (*Juglans sp.*), and deergrass (*Muhlenbergia* sp.). Riparian habitats adjacent to the Rio Grande (Fig. 7) are dominated by salt cedar (*Tamarix* sp.), giant reed (*Arundo donax*), common reed (*Phragmites australis*), tree tobacco (*Nicotiana glauca*), and various short grasses.

Juniper roughland (Fig. 8) occurs only sparsely at higher elevations in isolated areas of the park. Such areas include the northern rim of the Solitario and the slopes of Cienega Mountain. This habitat is composed of stands of red-berry juniper (*Juniperus pinchotii*) in rocky, upland terrain. Associated vegetation may include various scrub species such as ocotillo, creosote, acacia, and prickly pear cactus. See Butterwick and Lamb (1976), and Butterwick and Strong (1976*a*; 1976*b*; 1976*c*) for a comprehensive list of plants at BBRSP.

Figure 5. Typical desert grassland habitat of Big Bend Ranch State Park.

Figure 6. Typical riparian habitat found in the interior of Big Bend Ranch State Park.

Figure 7. Typical riparian habitat found along the Rio Grande of Big Bend Ranch State Park.

Figure 8. Juniper roughland habitat of Big Bend Ranch State Park.

MATERIALS AND METHODS

Data Acquisition

The majority of the information used in this study was obtained as a result of two years of field operations conducted at BBRSP. The focus of this field work involved the collection and preparation of mammals from numerous localities within the park boundaries.

Several methods of capture as presented by Jones et al. (1996) were used to collect mammals. The use of mist nets as outlined by Kunz and Kurta (1988) was the primary method used to obtain bats. At dusk, nets were strung across selected springs, streams, or other small bodies of water that occur throughout the park. In some instances, nets were set in dry areas that appeared to be potential flyways for bats. Nets were either left overnight and tended to at dawn the following morning or monitored throughout the night. On occasion, when opportunity permitted, bats simply were removed from their roost by hand.

Sherman live-traps baited with rolled oats were used extensively to capture rodents. Museum Special and Victor rat traps baited with peanut butter were used to a lesser degree. Line transects consisted of 30 to 250 traps set at 7 to 10 m intervals. On rare occasions, smaller arrays of traps were set in confined areas such as barns or sheds. Small arrays of Victor gopher traps were set in an effort to capture gophers. Traps typically were set approximately one hour before sundown and retrieved approximately one hour after sunrise the following morning.

Spring traps (Conibears, legholds), and wire mesh live traps (Havaharts) were used to capture carnivores. These traps were baited with small mammal carcasses or other scraps of meat, and sporadically set in arrays of 3 to 10 traps. They were set at sundown and checked the following morning at sunrise.

In addition to the aforementioned capture methods, mammals occasionally were taken with the use of firearms. Also, some mammal specimens were obtained by salvaging already dead individuals, or parts thereof, which were found while doing field work.

Despite rough topography, limited number and poor condition of roads, and unpredictable weather, every attempt was made to sample as much of the park and its various habitats as possible. Sampling localities were accessed by four wheel drive vehicle, horse, and helicopter, as well as on foot. A sampling locality can be defined as the location where an array of traps was set, where an individual mist net was erected, or where an individual specimen was acquired by any of the other methods. All localities were acquired using a Magellan Meridian hand held global positioning system (GPS). The unit is accurate to within 25 m (Anonymous, 1993). However, due to a potential risk to national security, the United States Department of Defense, which manages the system, periodically introduces a random error (termed Selective Availability or SA). When activated, SA reduces the accuracy of a position fix to within 100 m of the actual location 95 percent of the time (August, 1993; Kerr, 1996). Therefore, in this report all given localities should be considered accurate ±100 m. Each locality is based on Universal Transverse Mercator (UTM) coordinates. The globe is partitioned into 60 zones, each of which is 6° wide as projected from the Earth's center. All localities were taken in zone 13. An easting coordinate refers to the distance in meters east of a point 500,000 m west of the center of the zone. A northing coordinate is the distance in meters north of the Equator.

For each trapline, a GPS fix was taken near the center of the line, and the corresponding UTM coordinates were assigned to all specimens captured on the transect. For all other methods of collection, UTM fixes were taken at the exact site of collection.

The majority of mammals collected were retained as voucher specimens. In instances where an excessive number of a particular species was captured at the same locality, individuals were released following identification. Mammals retained were prepared as museum specimens in an appropriate manner. Most individuals were prepared as standard skin and skull specimens following Hall (1962) and DeBlase and Martin (1981). In certain cases where retaining the skin was not possible (excessive damage or decay in salvaged specimens), only the skull was kept. Likewise, if the skull

was excessively damaged, only the skin was retained. Some specimens were preserved in fluids. Tissue specimens consisting of skeletal muscle, liver, heart, and kidney were collected from selected individuals. Upon removal, tissues were temporarily frozen in liquid nitrogen pending deposition in an -80° C ultracold freezer for long-term storage. Samples of brain were collected from selected bats and carnivores, and submitted to the Texas Department of Health for rabies testing. Karyotypes of selected individuals were prepared following Robbins and Baker (1983). Stomach contents of selected bats were analyzed following Whitaker (1988). All voucher specimens, including frozen tissues, are deposited in the Natural Science Research Laboratory (NSRL) of the Museum of Texas Tech University (TTU).

While in the field, data pertaining to each mammal captured were entered into a spreadsheet/database program installed in a Macintosh Powerbook portable computer. The database structure, which was created using Microsoft Excel, version 3.0, was in accordance with documentation standards set forth by the American Society of Mammalogists (McLaren et al., 1996). The design of the database and a description of the database fields into which data were entered are presented in Appendix I.

In addition to data obtained from mammals collected in the field, information pertaining to this study was acquired by several other avenues. Often, mammals were encountered during the course of field work, but it was not possible or practical to collect them as specimens. These observations included mammals detected by sight, sound, or sign (scats, tracks). Also, useful information was acquired from observations of mammals reported by park personnel. Under these circumstances, data regarding each observation were recorded and entered into a separate database.

Additional information for this study was obtained by examining specimens of mammals from the vicinity of Big Bend Ranch. Collections of mammals surveyed included TTU; the Angelo State University Mammal Collection Laboratory; the Texas Cooperative Wildlife Collection, Texas A&M University; Sul Ross State University; the Museum of Southwestern Biology, University of New Mexico; and the United States National Museum. Only the collection at Sul Ross State University contained specimens from BBRSP. Data acquired from specimens housed at that institution, along with information obtained from a thorough review of the literature, were useful supplements to the data obtained in the field.

Data Analysis

Data were organized and sorted using the spreadsheet and database capabilities of Excel. In addition, this program was used to calculate all descriptive statistics presented in this document.

The Geographic Information System (GIS) at TPWD was used to analyze and map the distribution of the mammals at BBRSP. UTM coordinates were downloaded from Excel into ArcView software installed in a Sun SPARCstation 20 computer. These data will form the basis for a mammal layer added the BBRSP GIS database. Additional layers already present in the system include park boundaries, geologic formations, geologic faults, geologic symbols, roads and jeep trails, urban locations, hydrology, sediment samples, contours, and feature updates (Erickson, 1994). All distribution maps presented throughout this document were produced via this system.

Because a considerable effort was applied to trapping rodents, the ecological affinities of several rodents to vegetational communities were tested. Habitats considered were desert scrub, desert grassland, and riparian. Occasionally, rodents were taken in juniper woodland, but, as this habitat is scarce in BBRSP, sample sizes were too small to include this habitat in comparisons. Thus, for certain rodents, chi-square values for variables plotted against a resampled distribution obtained at 1000 iterations (Bruce, 1992; Simon, 1992) were used to determine if any differences in habitat use existed. The alpha level for this test was set at 0.05. If there was a significant difference detected (≤ 0.05), then a multiple-comparison chi-square test was used to determine which of the three habitats were responsible for the difference. The alpha level of rejection for this test was determined using the Bonferroni inequality formula,

$$\alpha = \frac{\alpha_{\chi^2}}{k}$$

where $\alpha_{\chi 2}$ is the original alpha level of the chi-square test used with all groups combined, and k is the number of individual treatment groups considered in the original test (Glantz, 1992). In this analysis, there were three treatment groups, or habitat types, and an original alpha level value of 0.05. Thus, the alpha level derived for these individual tests was

$$\alpha = \frac{0.05}{3} = 0.017$$

Jaccard's coefficient (Jaccard, 1912) similarity index was used to assess the interrelationship between the mammalian fauna of BBRSP with that of other regions within the Chihuahuan Desert. This index considers only presence-absence data, and bases similarity on the ratio of shared species to the total number of species present at both sites. It does not consider that the joint absence of a species contributes to the similarity of the two areas. The formula for Jaccard's coefficient (S_j) is:

$$S_j = a/(a+u)$$

where a is the number of species shared by the two areas under consideration, and u is the total number of unshared species in the two areas (Willig and Mares, 1989).

Species composition of bats was derived from the number of individuals of each species caught per net night, whereas the species composition of rodents was derived from the number captured per 100 trapnights. The percentage of total captures of each species also was determined for both rodents and bats. For rodents, only those species that were trapped with Sherman live traps or Museum Special snap traps were considered.

RESULTS OF FIELD WORK

Field work for this study commenced in January, 1994, and concluded in December, 1995. During this period, 303 specific localities throughout the park were sampled. All localities sampled are mapped in Figure 9, and specific localities for each sampling method used in this study are listed in Appendix II. Sampling efforts applied to these localities are summarized in Table 3. As a result of these efforts, a total of 1444 mammals, represented by 48 species, was acquired. Frozen tissues were collected from 411 specimens, representing

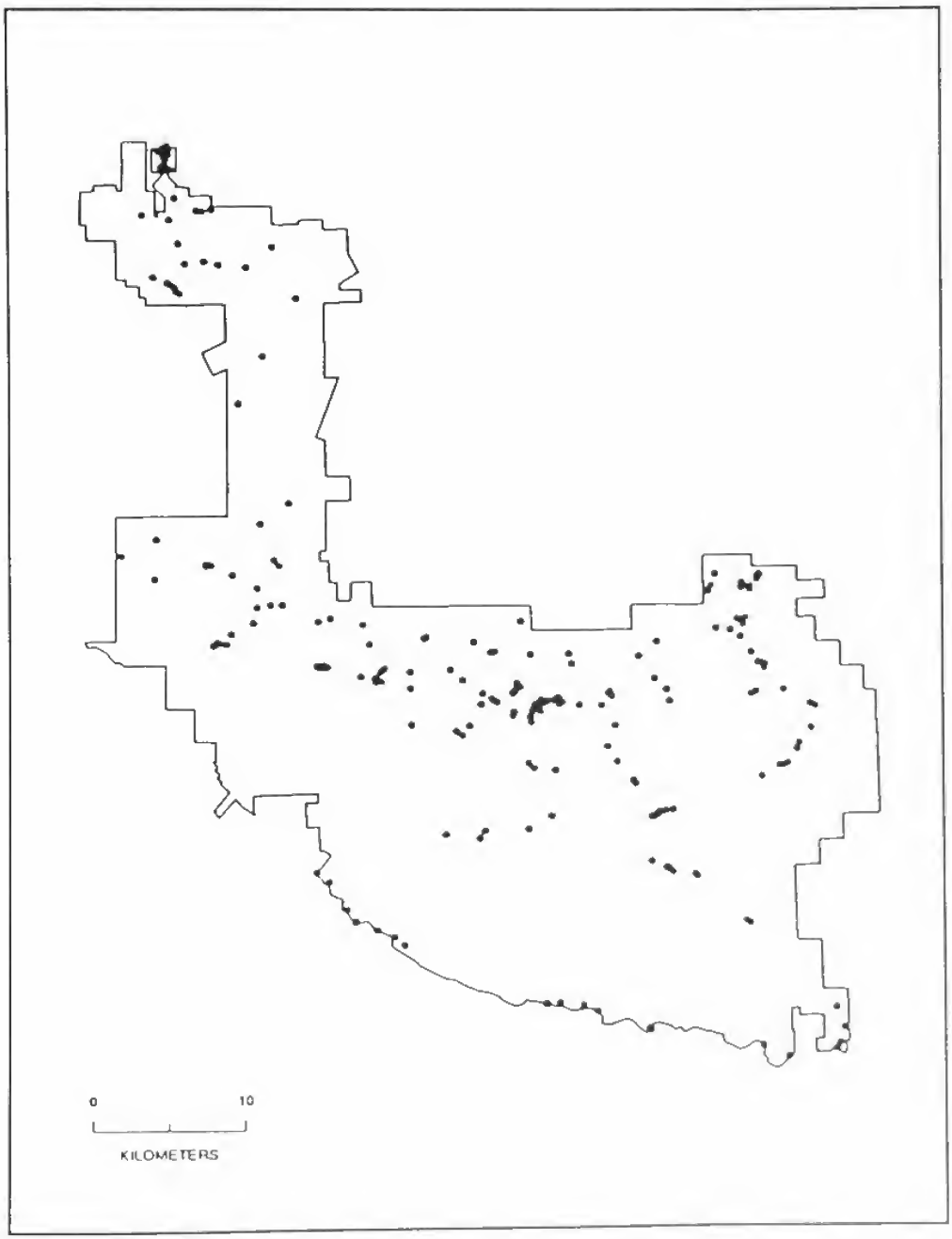

Figure 9. Localities where mammals were sampled at Big Bend Ranch State Park, Texas, during 1994 and 1995.

42 species. A list of mammals collected, along with the nature and quantity of specimens retained for each species, is presented in Table 4. In addition to information obtained from the collection of specimens, data pertaining to 88 observations of mammals were recorded. These observations are discussed in the accounts of species.

Table 3. Summary of efforts to collect mammals in Big Bend Ranch State Park during 1994 and 1995.

Method	Localities	Number of Lines	Number Set	Mammals Taken	Percent Success
Mist Nets	108	-	337	542	1.6
Traps:					
Shermans	168	198	11,597	797	6.9
Museum Specials	11	13	517	14	2.7
Rat	8	10	245	9	3.7
Gopher	7	12	45	6	13.3
Conibear	12	29	111	6	5.4
Havahart	16	24	55	3	5.5
Leghold	3	7	48	1	2.1
Firearms	32	-	-	44	-
Hand-capture	3	-	-	5	-
Salvaged	14	-	-	17	-

Table 4. Mammals, acquired along with voucher specimens and frozen tissues retained, as a result of field work at Big Bend Ranch State Park during 1994 and 1995. SS=skin and skull, SK=skull only, SO=skin only, AL=preserved in alcohol.

			Retained as Vouchers				
Species	Number Caught	Total	SS	SK	SO	AL	Tissues Collected
Mormoops megalophylla	131	123	123	0	0	0	47
Myotis californicus	21	21	21	0	0	0	14
Myotis ciliolabrum	1	1	1	0	0	0	0
Myotis thysanodes	2	2	2	0	0	0	2
Myotis velifer	16	16	16	0	0	0	8
Myotis yumanensis	4	4	4	0	0	0	4
Eptesicus fuscus	56	50	49	1	0	0	15
Pipistrellus hesperus	194	118	114	4	0	0	13
Pipistrellus subflavus	1	1	1	0	0	0	1
Lasiurus cinereus	6	6	6	0	0	0	4
Plecotus townsendii	11	10	10	0	0	0	9
Antrozous pallidus	44	44	44	0	0	0	9
Tadarida brasiliensis	77	54	54	0	0	0	8
Nyctinomops macrotis	1	1	1	0	0	0	1
Sylvilagus audubonii	8	8	8	0	0	0	2
Lepus californicus	10	10	10	0	0	0	2
Ammospermophilus interpres	2	2	2	0	0	0	2
Spermophilus spilosoma	3	3	2	0	0	1	2
Spermophilus variegatus	1	1	0	0	1	0	0
Thomomys bottae	2	2	2	0	0	0	1
Cratogeomys castanops	4	4	4	0	0	0	2
Perognathus flavus	80	76	76	0	0	0	25
Chaetodipus eremicus	160	111	111	0	0	0	30
Chaetodipus hispidus	3	3	3	0	0	0	3
Chaetodipus intermedius	13	13	13	0	0	0	9
Chaetodipus nelsoni	76	74	74	0	0	0	28
Dipodomys merriami	133	118	117	1	0	0	25
Reithrodontomys fulvescens	8	8	8	0	0	0	2
Reithrodontomys megalotis	11	11	11	0	0	0	6
Peromyscus eremicus	117	116	116	0	0	0	33
Peromyscus leucopus	71	70	70	0	0	0	45
Peromyscus maniculatus	59	58	58	0	0	0	18
Peromyscus pectoralis	56	55	55	0	0	0	13
Onychomys arenicola	10	10	10	0	0	0	6
Sigmodon hispidus	4	3	3	0	0	0	2
Sigmodon ochrognathus	1	1	1	0	0	0	1
Neotoma albigula	7	7	7	0	0	0	6
Neotoma mexicana	1	1	1	0	0	0	1
Neotoma micropus	12	11	11	0	0	0	3
Canis latrans	1	1	1	0	0	0	0
Urocyon cinereoargenteus	1	1	1	0	0	0	1
Bassariscus astutus	2	2	2	0	0	0	2
Procyon lotor	1	1	1	0	0	0	1
Conepatus mesoleucus	1	1	1	0	0	0	1
Mephitis mephitis	6	6	6	0	0	0	4
Tayassu tajacu	6	6	0	6	0	0	0
Odocoileus hemionus	8	8	0	8	0	0	0
Capra hircus	1	1	0	1	0	0	0
Total	1444	1254	1231	21	1	1	411

CHECKLIST OF SPECIES

The following checklist of mammals is divided into four groups: native species, nondomestic introduced species, domestic species, and species of postulated occurrence. The list of native species consists of 59 species of indigenous mammals known to occur within the boundaries of BBRSP as verified by any of the means described in the methods section. The list of nondomestic introduced species includes two wild bovids not native to BBRSP, but which now exist there as free-ranging populations following their introduction into the area by humans. The list of domestic species is comprised of seven mammals that have been domesticated by humans and are verified to occur in BBRSP. The list of species of postulated occurrence contains 27 mammals that, based on their overall distribution, may occur in BBRSP, but have not yet been documented there. Arrangement and nomenclature of taxa in the checklist are as presented in the accounts of species.

Native Species

Order Chiroptera
- Family Mormoopidae
  - *Mormoops megalophylla* (ghost-faced bat)
- Family Vespertilionidae
  - *Myotis californicus* (California myotis)
  - *Myotis ciliolabrum* (western small-footed myotis)
  - *Myotis thysanodes* (fringed myotis)
  - *Myotis velifer* (cave myotis)
  - *Myotis yumanensis* (Yuma myotis)
  - *Pipistrellus hesperus* (western pipistrelle)
  - *Pipistrellus subflavus* (eastern pipistrelle)
  - *Eptesicus fuscus* (big brown bat)
  - *Lasiurus cinereus* (hoary bat)
  - *Plecotus townsendii* (Townsend's big-eared bat)
  - *Antrozous pallidus* (pallid bat)
- Family Molossidae
  - *Tadarida brasiliensis* (Brazilian free-tailed bat)
  - *Nyctinomops macrotis* (big free-tailed bat)
  - *Eumops perotis* (western mastiff bat)

Order Lagomorpha
- Family Leporidae
  - *Sylvilagus audubonii* (desert cottontail)
  - *Lepus californicus* (black-tailed jackrabbit)

Order Rodentia
- Family Sciuridae
  - *Ammospermophilus interpres* (Texas antelope squirrel)
  - *Spermophilus spilosoma* (spotted ground squirrel)
  - *Spermophilus variegatus* (rock squirrel)
- Family Geomyidae
  - *Thomomys bottae* (Botta's pocket gopher)
  - *Cratogeomys castanops* (yellow-faced pocket gopher)
- Family Heteromyidae
  - *Perognathus flavus* (silky pocket mouse)
  - *Chaetodipus eremicus* (Chihuahuan Desert pocket mouse)
  - *Chaetodipus hispidus* (hispid pocket mouse)
  - *Chaetodipus intermedius* (rock pocket mouse)
  - *Chaetodipus nelsoni* (Nelson's pocket mouse)
  - *Dipodomys merriami* (Merriam's kangaroo rat)
  - *Dipodomys ordii* (Ord's kangaroo rat)
- Family Castoridae
  - *Castor canadensis* (American beaver)
- Family Muridae
  - *Reithrodontomys fulvescens* (fulvous harvest mouse)
  - *Reithrodontomys megalotis* (western pocket mouse)
  - *Peromyscus boylii* (brush mouse)
  - *Peromyscus eremicus* (cactus mouse)
  - *Peromyscus leucopus* (white-footed mouse)
  - *Peromyscus maniculatus* (deer mouse)
  - *Peromyscus pectoralis* (white-anklea mouse)
  - *Onychomys arenicola* (Mearns' grasshopper mouse)
  - *Sigmodon hispidus* (hispid cotton rat)
  - *Sigmodon ochrognathus* (yellow-nosed cotton rat)

Neotoma albigula (white-throated woodrat)
Neotoma mexicana (Mexican woodrat)
Neotoma micropus (southern plains woodrat)
Family Erethizontidae
Erethizon dorsatum (porcupine)
Order Carnivora
Family Canidae
Canis latrans (coyote)
Vulpes velox (kit fox)
Urocyon cinereoargenteus (common gray fox)
Family Ursidae
Ursus americanus (black bear)
Family Procyonidae
Bassariscus astutus (ringtail)
Procyon lotor (common raccoon)
Family Mustelidae
Taxidea taxus (American badger)
Mephitis mephitis (striped skunk)
Conepatus mesoleucus (common hog-nosed skunk)
Family Felidae
Felis concolor (mountain lion)
Lynx rufus (bobcat)
Order Artiodactyla
Family Dicotylidae
Tayassu tajacu (collared peccary)
Family Cervidae
Odocoileus hemionus (mule deer)
Odocoileus virginianus (white-tailed deer)
Family Antilocapridae
Antilocapra americana (pronghorn)

Nondomestic Introduced Species

Family Bovidae
Capra ibex (ibex)
Ammotragus lervia (Barbary sheep, aoudad)

Domestic Species

Order Carnivora
Family Canidae
Canis familiaris (domestic dog)
Family Felidae
Felis catus (domestic cat)
Order Perissodactyla
Family Equidae
Equus caballus (domestic horse)
Equus asinus (burro)
Order Artiodactyla
Family Suidae
Sus scrofa (domestic pig)
Family Bovidae
Bos taurus (domestic cow)
Capra hircus (domestic goat)

Species of Postulated Occurrence

Order Didelphimorphia
Family Didelphidae
Didelphis virginiana (Virginia opossum)
Order Insectivora
Family Soricidae
Notiosorex crawfordi (desert shrew)
Family Talpidae
Scalopus aquaticus (eastern mole)
Order Chiroptera
Family Phyllostomidae
Leptonycteris nivalis (Mexican long-nosed bat)
Family Vespertilionidae
Myotis auriculus (southwestern myotis)
Myotis lucifugus (little brown myotis)
Myotis volans (long-legged myotis)
Lasionycteris noctivagans (silver-haired bat)
Lasiurus blossevillii (western red bat)
Lasiurus borealis (eastern red bat)
Euderma maculatum (spotted bat)
Family Molossidae
Nyctinomops femorosaccus (pocketed free-tailed bat)
Order Lagomorpha
Family Leporidae
Sylvilagus floridanus (eastern cottontail)
Order Rodentia
Family Sciuridae
Spermophilus mexicanus (Mexican ground squirrel)
Family Heteromyidae
Dipodomys spectabilis (banner-tailed kanganroo rat)

Family Muridae
- *Reithrodontomys montanus* (plains harvest mouse)
- *Peromyscus nasutus* (northern rock mouse)
- *Sigmodon fulviventer* (tawny-bellied cottonrat)
- *Rattus norvegicus* (Norway rat)
- *Rattus rattus* (roof rat)
- *Mus musculus* (house mouse)
- *Ondatra zibethicus* (common muskrat)

Order Carnivora
- Family Procyonidae
  - *Nasua narica* (white-nosed coati)
- Family Mustelidae
  - *Mustela frenata* (long-tailed weasel)
  - *Spilogale gracilis* (western spotted skunk)
  - *Mephitis macroura* (hooded skunk)
- Family Felidae
  - *Felis pardalis* (ocelot)

FAUNAL ANALYSIS

Species Diversity and Similarity

The documented native mammalian diversity of BBRSP was evaluated and compared with those of eight other areas within the Chihuahuan Desert. An effort was made to include areas throughout the Chihuahuan Desert that have a relatively well known mammalian fauna. Specific sites selected (with references used to construct faunal lists used in analysis in parentheses) were as follows: Big Bend National Park, Texas (Borell and Bryant, 1942; Easterla, 1973; Anonymous, 1989; Jones et al., 1993); the Davis Mountains region, Texas (Blair, 1940; Genoways et al., 1979; Stangl, 1992*a*; 1992*b*); the Sierra Vieja region, Texas (Blair and Miller, 1949; Genoways et al., 1979; Genoways and Baker, 1988; specimens in the collection at TTU); Guadalupe Mountains National Park, Texas (Davis, 1940; Genoways et al., 1979); northwest Coahuila, Mexico (Baker, 1956); northeast Chihuahua, Mexico (Anderson, 1972); Crockett County, Texas (Goetze, 1995); and the Animas Mountains region, New Mexico (Cook, 1986).

Native species of mammals known to occur in the nine areas considered for analyses (including BBRSP) are summarized in Table 5. Using this data matrix, Jaccard's coefficient similarity index was calculated for each possible pair-wise comparison. The richness and interrelationship of the mammalian faunas of the nine areas considered are summarized in Table 6.

Of the nine areas analyzed, Big Bend National Park and the Animas Mountains region were the most diverse with 70 species of mammals occurring in each area. Crockett County was the least diverse with 41 species. With 59 species, BBRSP ranked sixth in terms of species richness. Four of the five areas that ranked above BBRSP were larger in total area. Because the number of species in an area is positively correlated with the size of the area (Williamson, 1981; Wilson, 1992) area, no doubt, was a factor in this case. In addition, areas with large ranges of elevations tend to have greater species diversity than those comprised of lower variability of elevations (Williamson, 1981). This concept is consistent with my results, as all areas with a diversity level greater than that of BBRSP contained more high-elevation (>1500 m) mountainous regions.

Big Bend National Park and the Davis Mountains region ranked first and second, respectively, in terms of a mammalian fauna resembling that of BBRSP. Both of these areas are within close proximity to BBRSP, and there are no imposing barriers separating them. Guadalupe Mountains National Park, the Sierra Vieja region, northwestern Coahuila, and northeastern Chihuahua all had intermediate levels of similarity with BBRSP. The former two are further distances away, but are included within the Trans-Pecos, and no significant dispersal barrier exists between sites. Coahuila and Chihuahua are adjacent to BBRSP, but are separated from BBRSP by the Rio Grande. This river has been shown to act as a major filter barrier to the dispersal of Chihuahuan Desert mammals (Schmidly, 1977*b*). The least similar sites were the Animas Mountains and Crockett County. Both are situated considerable distances from BBRSP. Furthermore, imposing barriers occur between the sites. Crockett County lies immediately to the east of the Pecos River, which is known to affect the distribution of mammals between the Trans-Pecos and areas to the east (Hollander et al., 1990). The Animas Mountains region of southwestern New Mexico is the most distant site analyzed, and several potential distributional barriers, including the Rio Grande, lie in-between.

Species Composition

Whereas species diversity or richness applies to the number and types of species present in an area, species composition refers to the relative abundance of each species (Hall and Willig, 1994). Because a considerable effort was applied in obtaining bats and rodents, it was possible to calculate indices of species composition for members of these taxa. The species composition of bats in BBRSP was derived from the number of individuals of each species caught per net night, whereas the species composition of rodents is based on number captured per 100 trapnights. The percentage of total captures of each species also was determined for both rodents and bats. For rodents, only those species readily trapped with Sherman live traps or snap traps were con-

Table 5. Matrix depicting the mammalian fauna of nine areas within the Chihuahuan Desert. Areas represented are: Big Bend Ranch State Park, Texas (BBR), Big Bend National Park, Texas (BBN), the Davis Mountains region, Texas (DM), the Sierra Vieja region, Texas (SV), Guadalupe Mountains National Park, Texas (GM), northwestern Coahuila, Mexico (CO), northeastern Chihuahua, Mexico (CH), Crockett County, Texas (CC), and the Animas Mountains region, New Mexico (AM).

Species	BBR	BBN	DM	SV	GM	CO	CH	CC	AM
Didelphis virginiana		+							+
Sorex arizonae									+
Sorex milleri						+			
Notiosorex crawfordi		+	+			+			+
Scalopus aquaticus						+			
Mormoops megalophylla	+	+	+	+					
Leptonycteris curasoae									+
Leptonycteris nivalis		+				+			
Choeronycteris mexicana									+
Myotis auriculus									+
Myotis californicus	+	+		+	+	+	+		+
Myotis ciliolabrum	+	+	+	+	+	+	+		+
Myotis thysanodes	+	+	+	+	+	+	+		+
Myotis velifer	+	+	+	+	+	+	+	+	+
Myotis volans		+	+	+	+	+			+
Myotis yumanensis	+	+	+	+		+	+		
Lasionycteris noctivagans			+		+				+
Pipistrellus hesperus	+	+	+	+	+	+	+		+
Pipistrellus subflavus	+								
Eptesicus fuscus	+	+	+	+	+	+			+
Lasiurus blossevillii				+					
Lasiurus borealis		+	+	+					+
Lasiurus cinereus	+	+	+	+	+	+	+		+
Lasiurus ega						+			+
Euderma maculatum		+							
Plecotus townsendii	+	+		+	+	+	+		+
Antrozous pallidus	+	+	+	+	+	+	+	+	+
Tadarida brasiliensis	+	+	+	+	+	+	+	+	+
Nyctinomops femorosaccus		+							
Nyctinomops macrotis	+	+	+	+	+				+
Eumops perotis	+	+							
Dasypus novemcinctus								+	
Sylvilagus audubonii	+	+	+	+	+	+	+	+	+
Sylvilagus floridanus		+	+	+	+	+		+	+
Lepus californicus	+	+	+	+	+	+	+	+	+
Lepus callotis									+
Tamias canipes					+				
Tamius dorsalis						+	+		+
Ammospermophilus harrisii									+
Ammospermophillus interpres	+	+		+	+	+	+	+	
Spermophilus mexicanus		+	+						
Spermophillus spilosoma	+	+	+		+	+	+		+
Spermophillus variegatus	+	+	+	+	+	+	+	+	+
Siurus niger								+	
Cynomys ludovicianus			+	+	+			+	
Thomomys bottae	+	+	+	+	+	+	+	+	+
Thomomys umbrinus									+
Cratogeomys castanops	+	+	+	+	+	+	+	+	
Perognathus flavus	+	+	+	+	+	+	+	+	+
Chaetodipus eremicus	+	+	+	+	+	+	+	+	
Chaetodipus hispidus	+		+		+	+		+	+

Table 5. (continued)

Species	BBR	BBN	DM	SV	GM	CO	CH	CC	AM
Chaetodipus intermedius	+				+		+		+
Chaetodipus nelsoni	+	+	+	+		+	+		
Chaetodipus penicillatus									+
Dipodomys merriami	+	+	+	+	+	+	+	+	+
Dipodomys nelsoni						+	+		
Dipodomys ordii	+	+	+		+		+	+	+
Dipodomys spectabilis			+	+	+				+
Castor canadensis	+	+				+	+	+	
Reithrodontomys fulvescens	+	+	+			+	+		+
Reithrodontomys megalotis	+	+	+	+	+	+	+		+
Reithrodontomys montanus			+				+		
Peromyscus attwateri								+	
Peromyscus boylii	+	+	+		+	+			+
Peromyscus eremicus	+	+	+	+	+	+	+		+
Peromyscus leucopus	+	+	+	+	+	+	+	+	+
Peromyscus maniculatus	+	+	+	+	+	+	+		+
Peromyscus nasutus					+	+			
Peromyscus pectoralis	+	+	+	+	+	+	+	+	
Peromyscus truei					+				
Baiomys taylori									+
Onychomys arenicola	+	+	+		+		+	+	+
Onychomys leucogaster			+			+	+	+	
Onychomys torridus									+
Sigmodon fulviventor			+				+		+
Sigmodon hispidus	+	+	+		+	+	+	+	+
Sigmodon ochrognathus	+	+	+	+		+			+
Neotoma albigula	+	+	+	+	+	+	+	+	+
Neotoma goldmani							+		
Neotoma mexicana	+	+	+	+	+	+			+
Neotoma micropus	+	+	+	+	+	+		+	
Microtus mexicanus					+				
Ondatra zibethicus							+		
Erethizon dorsatum	+	+	+	+	+	+		+	+
Canis latrans	+	+	+	+	+	+	+	+	+
Vulpes velox	+	+	+					+	+
Vulpes vulpes								+	
Urocyon cinereoargenteus	+	+	+	+	+	+	+	+	+
Ursus americanus	+	+	+		+	+			+
Bassariscus astutus	+	+	+	+	+	+		+	+
Procyon lotor	+	+	+	+	+	+		+	+
Nasua narica		+							
Mustella frenata		+			+				
Taxidea taxus	+	+	+	+	+	+			+
Spilogale gracilis						+			+
Spilogale putorius		+	+	+	+				
Mephitis macroura		+	+	+		+			+
Mephitis mephitis	+	+	+	+	+	+	+	+	+
Conepatus mesoleucus	+	+	+	+	+			+	+
Felis concolor	+	+	+	+	+	+	+	+	+
Lynx rufus	+	+	+	+	+	+		+	+
Tayassu tajacu	+	+	+	+		+	+	+	+
Cervus elephus					+				
Odocoieus hemionus	+	+	+	+	+	+	+		+
Odocoileus virginianus	+	+	+		+	+	+	+	+
Antilocapra americana	+	+	+	+	+		+	+	+
Ovis canadensis		+			+	+			

Table 6. Matrix depicting the diversity and similarity of the mammalian fauna among nine geographic regions within the Chihuahuan Desert. Bold-faced numbers running diagonally from the upper left to the lower right represent the number of species of mammals verified to occur in a given area. Entries to the left of the diagonal represent calculated Jaccard's coefficient of similarity between two areas, whereas entries to the right depict the number of mammal species shared by two particular areas. Definitions of abbreviations are the same as in Table 5.

Geographic Region	BBR	BBN	DM	SV	GM	CO	CH	CC	AM
Big Bend Ranch State Park, Texas	**59**	56	52	45	49	49	41	34	48
Big Bend National Park, Texas	0.77	**70**	58	50	52	54	40	29	52
Davis Mountain Region, Texas	0.72	0.75	**65**	49	51	50	39	35	53
Sierra Vieja Region, Texas	0.67	0.68	0.71	**53**	45	44	32	28	42
Guadalupe Mountains National Park, Texas	0.68	0.65	0.67	0.64	**62**	47	36	33	48
Northwestern Coahuila, Mexico	0.67	0.68	0.64	0.61	0.60	**63**	40	31	48
Northeastern Chihuahua, Mexico	0.62	0.51	0.53	0.46	0.49	0.56	**48**	27	36
Crockett County, Texas	0.52	0.40	0.49	0.42	0.47	0.42	0.39	**41**	29
Animas Mountains Region, New Mexico	0.59	0.59	0.65	0.52	0.57	0.56	0.44	0.35	**70**

Table 7. Species composition of bats at Big Bend Ranch State Park based on the results 337 net nights.

Species	Number Caught	Number per Net	Percent of all Captures
Mormoops megalophylla	131	0.389	23.2
Myotis californicus	21	0.062	3.7
Myotis ciliolabrum	1	0.003	0.2
Myotis thysanodes	2	0.006	0.4
Myotis velifer	12	0.036	2.7
Myotis yumanensis	2	0.006	0.4
Eptesicus fuscus	55	0.163	9.9
Pipistrellus hesperus	180	0.534	34.4
Pipistrellus subflavus	1	0.003	0.2
Lasiurus cinereus	6	0.018	1.1
Plecotus townsendii	9	0.027	2.0
Antrozous pallidus	44	0.131	7.8
Tadarida brasiliensis	77	0.228	13.7
Nyctinomops macrotis	1	0.003	0.2

sidered. The results of these species composition calculations for bats and rodents are presented in Tables 7 and 8, respectively. Discussions on the composition of each species are included in the accounts of species.

Table 8. Species composition of rodents at Big Bend Ranch State Park based on the results of 12,359 trapnights. Only those species readily trapped with Sherman or snap traps are included.

Species	Number Caught	Number per 100 Trapnights	Percent of all Captures
Perognathus flavus	80	0.647	9.8
Chaetodipus eremicus	160	1.295	19.5
Chaetodipus hispidus	3	0.024	0.4
Chaetodipus intermedius	13	0.105	1.6
Chaetodipus nelsoni	76	0.615	9.3
Dipodomys merriami	133	1.076	16.2
Reithrodontomys fulvescens	8	0.065	1.0
Reithrodontomys megalotis	11	0.089	1.3
Peromyscus eremicus	114	0.922	13.9
Peromyscus leucopus	71	0.574	8.7
Peromyscus maniculatus	59	0.477	7.2
Peromyscus pectoralis	56	0.453	6.8
Onychomys arenicola	10	0.081	1.2
Sigmodon hispidus	4	0.032	0.5
Sigmodon ochrognathus	1	0.008	0.1
Neotoma albigula	7	0.057	0.9
Neotoma mexicana	1	0.008	0.1
Neotoma micropus	12	0.097	1.5

KEY TO THE SPECIES

The following key to the species of mammals is based on both external and cranial characters. Descriptions apply to non-aberrant, adult individuals. The key includes native mammals known to occur in BBRSP, as well as introduced species, domestic species, and species of postulated occurrence. In addition two extirpated species, the gray wolf (*Canis lupus*) and the bighorn sheep (*Ovis canadensis*), have been included because both species currently are under consideration for reintroduction into the area.

Once an identification is made using the key, the user should refer to the account of the species in the following section. Information in the account regarding distribution, description, and habitat affinities may help in confirming or discrediting an identification.

Data acquired during this study, along with information provided by Anderson (1972), Schmidly (1977*a*), Cornely et al. (1981), DeBlase and Martin (1981), Glass (1981), Hall (1981), Nowak (1991), Jones and Manning (1992), and Davis and Schmidly (1994) were used to construct this key.

1 Forelimbs modified as wings 2
1' Forelimbs not modified as wings 25

2 Prominent nose leaf at end of elongated snout; molars 2/2 ..... *Leptonycteris nivalis*
2' Nose leaf absent; molars 3/3 3

3 Tail protruding from dorsal surface of uropatagium; conspicuous grooves and flaps on chin;braincase of skull broader than long ..... *Mormoops megalophylla*
3' Tail extending through or beyond uropatagium; grooves or flaps on chin absent; braincase of skull longer than broad 4

4 Posterior third of tail extending beyond uropatagium; palate terminating slightly behind third upper molar 5
4' Tail terminating at free edge of uropatagium; palate extending well beyond third upper molar 8

5 Base of ears not fused at midline of head; incisors 1/3 or 1/2 ..... *Tadarida brasiliensis*
5' Base of ears fused at midline of head; incisors 1/2 6

6 Vertical wrinkles on lips absent; forearm greater than 70 mm; greatest length of skull greater than 30 mm ..... *Eumops perotis*
6' Vertical wrinkles on lips present; forearm less than 70 mm; greatest length of skull less than 30 mm 7

7 Forearm greater than 52 mm; greatest length of skull greater than 21 mm ..... *Nyctinomops macrotis*
7' Forearm less than 52 mm; greatest length of skull less than 21 mm ..... *Nyctinomops femorosaccus*

8 Ears large (greater than 23 mm) 9
8' Ears not noticeably large (less than 23 mm) 11

9 Color black, with three large, white spots on dorsum ..... *Euderma maculatum*
9' Color light brown or pale yellow 10

10 Color light brown; conspicuous lumps present on both sides of snout; incisors 2/3; premolars 2/3; total teeth, 36 ..... *Plecotus townsendii*
10' Color pale yellow; conspicuous lumps absent from sides of snout; incisors 1/2; premolars 1/2; total teeth 28 ..... *Antrozous pallidus*

11 Anterior third or more of dorsal surface of uropatagium hairy 12
11' Entire dorsal surface of uropatagium naked or only scantly haired 15

12 Color black, with many individual hairs tipped with silver; incisors 2/3 ..... *Lasionycteris noctivagans*
12' Color not as above; incisors 1/3 13

13 Color dark brown with considerable white frosting; forearm greater than 45 mm; greatest length of skull usually greater than 15 mm ..... *Lasiurus cinereus*
13' Color reddish; forearm less than 45 mm; greatest length of skull less than 15 mm 14

14 Hairs tipped with white; dorsal surface of uropatagium entirely haired ..... *Lasiurus borealis*
14' Hairs not tipped with white; posterior third of dorsal surface of uropatagium naked or only sparsely haired ..... *Lasiurus blossevillii*

15 Tragus short, curved, and blunt 16
15' Tragus long, straight, and pointed 17

16 Color brown; size large (forearm greater than 40 mm; greatest length of skull greater than 17 mm); premolars 1/2 ..... *Eptesicus fuscus*
16' Color grayish; size small (forearm less than 32 mm; greatest length of skull less than 14 mm); premolars 2/2 ..... *Pipistrellus hesperus*

17 Dorsal fur tricolored, black at the base, yellowish brown in the middle, dark brown at the tips; dactylopatagium minus much paler than remainder of wing membrane; premolars 2/2 ..... *Pipistrellus subflavus*
17' Dorsal fur uni- or bicolored, lacking a light middle band; wing membrane uniform in color; premolars 2/3 or 3/3 18

18 Calcar with a well-developed keel 19
18' Calcar without a well-developed keel 21

19 Color dark brown; size large (forearm greater than 36 mm); underside of wing membrane heavily furred to elbow ..... *Myotis volans*
19' Color light brown to reddish; size small (forearm less than 36 mm); underside of wing membrane not furred to elbow 20

20 Color usually reddish; braincase rising sharply above rostrum presenting a prominent forehead ..... *Myotis californicus*
20' Color usually buff brown, less reddish; braincase rising gently above rostrum presenting a flattened appearing skull ..... *Myotis ciliolabrum*

21 Short, stiff hairs present on free edge of uropatagium ..... *Myotis thysanodes*
21' Hairs absent from free edge of uropatagium 22

22 Ears relatively large (greater than 17 mm) ..... *Myotis auriculus*
22' Ears relatively short (less than 17 mm) 23

23 Forearm greater than 40 mm ..... *Myotis velifer*
23' Forearm less than 40 mm 24

24 Dorsal pelage dark brown, usually with a slight sheen; forearm greater than 36 mm ..... *Myotis lucifugus*
24' Dorsal pelage buff or light gray; forearm less than 36 mm ..... *Myotis yumanensis*

25 Hooves present on one or more toes of each foot 26
25' Hooves absent, toes usually clawed 37

26 One large hoof on each foot 27
26' Two or more hooves on each foot 28

27 Color variable, but usually without a dark cross on shoulders; mane usually of long, hanging hairs; facial part of skull long ..... *Equus caballus*
27' Color usually grayish, usually with a dark cross on shoulders; hairs of mane usually erect; facial part of skull shorter ..... *Equus asinus*

28 Body short, pig-like; end of nose a flat, round disk; upper incisors and canines present; appendages on frontal bones absent; postorbital bar incomplete 29
28' Body taller, not pig-like; end of nose not a flat, round disk; upper incisors and canines absent; appendages on frontal bones, at least in males; postorbital bar complete 30

29 Three toes on each hind foot; yellowish collar present above shoulders; upper canines straight, directed downward; incisors 2/3; premolars 3/3 ..... *Tayassu tajacu*
29' Four toes on each hind foot; yellowish collar above shoulders absent; upper canines curved outward and upward; incisors 3/3; premolars 4/4 ..... *Sus scrofa*

30 Frontal appendages antlers, composed entirely of bone and arising from the skull well posterior of orbits, present only in males, and shed annually; rostral fenestrations nearly as wide as long 31
30' Frontal appendages horns, composed of bony core surrounded by sheath of fused hair, present in both sexes, bony core not shed; rostral fenestrations absent, or if present long and narrow 32

31 Tail tipped with black, white or buff above; antlers dichotomously branched; ears large (about two-thirds length of head); preorbital pit deep ..... *Odocoileus hemionus*

31' Tail brown above, white below, with sides fringed in white; antlers one main beam from which single, unbranched tines arise; ears smaller (about half the length of head); preorbital pit shallow ..... *Odocoileus virginianus*

32 Two white bands across throat area; horn core with sharp anterior edge; sheath forked with small anterior projection (in males only), and shed annually; rostral fenestrations present; lacrimal not articulating with nasal ..... *Antilocapra americana*

32' White bands across throat area absent; horn core with rounded anterior edge; sheath never forked, and not shed; rostral fenestrations absent; lacrimal articulating with nasal 33

33 Size large (total length greater than 1800 mm); horns sweeping laterally and anteriorly ..... *Bos taurus*

33' Size small to medium (total length less than 1800 mm); horns curling posteriorly and downward 34

34 Beard present on chin (at least in males) 35

34' Ventral mane may be present, but beard is absent 36

35 Color reddish-tan to brown, often with whitish patches; horns with prominent transverse ridges ..... *Capra ibex*

35' Color variable; horns relatively smooth, not broken with transverse ridges ..... *Capra hircus*

36 Conspicuous white patch on rump; long, ventral mane absent; canines 0/1 ..... *Ovis canadensis*

36' White rump patch absent; long, ventral mane present; canines 0/0 ..... *Ammotragus lervia*

37 Canines present; no diastema between incisors and cheek teeth 38

37' Canines absent; conspicuous diastema between incisors and cheek teeth 59

38 Tail prehensile; incisors 5/4; hallux opposable and without claw; abdominal pouch in females; medially inflected angular process of dentary ..... *Didelphis virginiana*

38' Tail not prehensile; incisors 3/3 or less; hallux not opposable; all toes with claws; abdominal pouch absent; angular process of dentary not inflected 39

39 Size small (total length less than 200 mm); snout highly flexible; eyes proportionately small; canines proportionately small 40

39' Size larger (total length greater than 200 mm); snout usually not highly flexible; eyes proportionately large; canines proportionately large 41

40 Size rather small (total length less than 125 mm); front feet small and normal-shaped; first upper incisor large and procumbent with small accessory cusp behind primary cusp; zygomatic arch absent ..... *Notiosorex crawfordi*

40' Size larger (total length greater than 125 mm); front feet enlarged and paddle-shaped; first upper incisor not large and procumbent, and without small accessory cusp behind primary cusp; zygomatic arch present ... *Scalopus aquaticus*

41 Body cat-like; claws retractile; molars 1/1 42
41' Body not cat-like; claws usually not retractile; molars greater than 1/1 45

42 Size large (total length greater than 1500 mm); color uniform light brown or grayish ..... *Felis concolor*
42' Size smaller (total length less than 1500 mm); color and pattern variable 43

43 Dorsal pattern spotted; tail short; premolars 2/2 ..... *Lynx rufus*
43' Dorsal pattern may be spotted or not; tail usually long; premolars 3/2 44

44 Size small (greatest length of skull less than 105 mm); dorsal pattern highly variable, but usually not spotted; tail usually long, but may be short ..... *Felis catus*
44' Size medium (greatest length of skull greater than 105 mm); dorsal pattern heavily spotted; tail always long ..... *Felis pardalis*

45 Body dog-like; hind foot with four toes; total number of teeth 42 46
45' Body not dog-like; hind foot with five toes; total number of teeth greater than 42, or if 42, cheek teeth flattened and without sharp cusps 50

46 Fur may be short or long; lateral view of dorsal profile of skull presents a bulging forehead ..... *Canis familiaris*
46' Fur long; lateral view of dorsal profile of skull relatively straight 47

47 Size medium to large (weight greater than 9000 g, hind foot greater than 170 mm, greatest length of skull greater than 200 mm) 48
47' Size smaller (weight less than 9000 g, hind foot less than 170 mm, greatest length of skull less than 200 mm) 49

48 Size large (weight greater than 18,000 g, hind foot greater than 200 mm), greatest diameter of upper canine greater than 11 mm ..... *Canis lupus*
48' Size medium (weight less than 18,000 g, hind foot less than 200 mm), greatest diameter of upper canine less than 11 mm ..... *Canis latrans*

49 Color dark gray with white throat and rusty sides; black stripe present along dorsum of tail; ears normal; temporal ridge lyre-shaped; lower margin of dentary anterior to angular process with truncated indentation or "step" .... *Urocyon cinereoargenteus*
49' Color buffy gray with clear buff at sides, midbelly, and under tail; tail tipped in black but lacks dorsal stripe; ears large; temporal ridge not lyre-shaped; lower margin of dentary smooth ..... *Vulpes velox*

50 Size large (weight greater than 50,000 g); tail short (shorter than hind foot); total teeth 42 ..... *Ursus americanus*
50' Size smaller (weight less than 50,000 g); tail long (longer than hind foot); total teeth less than 42 51

51 Tail with alternating dark and light rings; molars 2/2; total number of teeth 40 52
51' Tail without alternating dark and light rings; molars 1/2; total number of teeth 38 or less 54

52 Tail long (as long or longer than head and body), and with 14-16 alternating black and white rings and a back tip; hind foot less than 80 mm; bony template terminating just posterior to last upper molar ..... *Bassariscus astutus*

52' Tail shorter (shorter than head and body), and with 6-7 alternating dark and light rings; hind foot greater than 85 mm; bony template terminating far posterior to last upper molar 53

53 Flexible snout extending far beyond mouth; rings on tail inconspicuous; rostrum noticeably elongated; conspicuous diastema between canine and first upper premolar ..... *Nasua narica*

53' Snout not as above; rings on tail conspicuous; rostrum only slightly elongated; diastema between canine and first upper premolar absent ..... *Procyon lotor*

54 Body thick; tail short (about as long as hind foot); braincase triangular in shape; upper molar triangular in shape ..... *Taxidea taxus*

54' Body not thick; tail long (conspicuously longer than hind foot); braincase not triangular in shape; upper molar quadrate or transversely elongate 55

55 Color light brown; upper molar transversely placed and dumbbell-shaped; bony palate extending far beyond molar ..... *Mustela frenata*

55' Color black and white; upper molar quadrate or subquadrate; bony palate extending only slightly beyond molar 56

56 Dorsum with single broad white stripe from head to tail; no white on forehead; large flexible nose pad present; premolars 2/3; total teeth 32 ..... *Conepatus mesoleucus*

56' Dorsum usually with two or more (rarely one) white stripes; small white stripe or spot on forehead; large flexible nose pad absent; premolars 3/3; total teeth 34 57

57 Dorsum with six distinct continuous or broken white stripes; white spot on forehead; greatest length of skull less than 65 mm; small postorbital process present ..... *Spilogale gracilis*

57' Dorsum not as above; white line on forehead; greatest length of skull greater than 65 mm; postorbital process absent 58

58 Dorsal stripe bifurcated; sides black; long hairs on neck and back of head absent; small tympanic bulla ..... *Mephitis mephitis*

58' Dorsal stripe pattern variable, either two narrow lateral stripes, a single solid central stripe, or a combination of the two; long hairs on neck and back forming hood; larger tympanic bulla ..... *Mephitis macroura*

59 Size larger; incisors 2/1; maxillary fenestrations present 60

59' Size smaller; incisors 1/1; maxillary fenestrations absent 62

60 Ears large (greater than 100 mm); tail with black dorsal stripe; supraorbital process broad, triangular in shape; interparietal indistinct, fused to parietal ..... *Lepus californicus*

60' Ears shorter (less than 100 mm); tail entirely white; supraorbital process narrow, strap-like, often fused to parietal posteriorly; interparietal distinct, not fused to parietal 61

61 Ears greater than 58 mm; hind foot less than 90 mm; auditory bulla large, with rough surface ..... *Sylvilagus audubonii*
61' Ears less than 58 mm; hind foot greater than 90 mm; auditory bulla small, with smooth surface ..... *Sylvilagus floridanus*

62 Dorsal hairs modified as sharp quills; infraorbital foramen larger than foramen magnum ..... *Erethizon dorsatum*
62' Dorsal hairs normal, not modified as quills; infraorbital foramen smaller than foramen magnum 63

63 Tail dorsal-ventrally compressed and paddle-shaped; hind foot completely webbed; skull with distinct basioccipital pit ..... *Castor canadensis*
63' Tail normal, not flattened or paddle-shaped; hind foot not webbed, or if webbed, only partially so; basioccipital pit absent 64

64 External fur-lined cheek pouches present; infraorbital foramen on lateral surface of rostrum 65
64' External fur-lined cheek pouches absent; infraorbital foramen at junction of rostrum and zygomatic plate 74

65 Front foot much larger than hind foot; ears inconspicuous; tail short, less than half the length of body; infraorbital foramen not perforate 66
65' Front foot smaller than hind foot; ears conspicuous; tail longer, greater than half the length of body; infraorbital foramen perforate 67

66 Size smaller; feet light in color; claws on front foot small and slender; anterior surface of upper incisor smooth, lacking longitudinal groove ..... *Thomomys bottae*
66' Size larger; feet dark in color; claws on front foot large and long; anterior surface of upper incisor with a single deep groove ..... *Cratogeomys castanops*

67 Hind foot relatively large (greater than twice as long as front foot); mastoid bulla markedly inflated; interparietal reduced, much longer than broad 68
67' Hind foot relatively small (less than twice as long as front foot); mastoid bulla only moderately inflated; interparietal not markedly reduced, at least as broad as long 70

68 Size large (total length greater than 300 mm); prominent white tip at end of tail ..... *Dipodomys spectabilis*
68' Size smaller (total length less than 300 mm); prominent white tip at end of tail absent 69

69 Hind foot with five toes ..... *Dipodomys ordii*
69' Hind foot with four toes ..... *Dipodomys merriami*

70 Size small (total length less than 135 mm); pelage silky; mastoid bulla inflated so that it encroaches dorsal surface of skull and extends posterior beyond occiput ..... *Perognathus flavus*
70' Size larger (total length greater than 135 mm); pelage not silky, often with bristles; mastoid bulla less inflated mostly restricted to lateral surface of skull, not extending posterior beyond occiput 71

71 Weight greater than 30 g; tail relatively short (less than length of head and body), and without terminal tuft; greatest length of skull greater than 28 mm ..... *Chaetodipus hispidus*

71' Weight less than 30 g; tail relatively long (greater than length of head and body), and with terminal tuft; greatest length of skull less than 28 mm 72

72 Rump with numerous conspicuous spines projecting beyond normal guard hairs; small white patch present at base of ear; ..... *Chaetodipus nelsoni*

72' Rump spines absent, or if present, fewer and less conspicuous; small white patch at base of ear absent; 73

73 Rump spines absent; interparietal separated from mastoid bulla by thin projections of the parietal and supraoccipital ..... *Chaetodipus eremicus*

73' Weak rump spines present; interparietal in contact with mastoid bulla, or nearly so ..... *Chaetodipus intermedius*

74 Body squirrel-like; prominent postorbital process present; four cheek teeth on dentary; infraorbital foramen a small hole, positioned above midline of rostrum 75

74' Body rat- or mouse-like; postorbital process absent; three cheek teeth on dentary; infraorbital foramen slit-like, positioned above midline of rostrum 78

75 Upper parts mottled grayish brown with head and upper back blackish, not spotted or striped ..... *Spermophilus variegatus*

75' Upper parts spotted or striped 76

76 Upper parts grayish with a single white stripe on each side; auditory bulla large; premolar reduced ..... *Ammospermophilus interpres*

76' Upper parts with spots; auditory bulla normal in size; premolar well-developed 77

77 Spots in 10 or more distinct rows; tail relatively long (about three times the length of hind foot) and moderately bushy ..... *Spermophilus mexicanus*

77' Spots randomly scattered, never in distinct rows; tail relatively short (about twice the length of hind foot) and not bushy ..... *Spermophilus spilosoma*

78 Tail always naked and scaly; cheek teeth cuspidate, with cusps of first two molars situated in three longitudinal rows 79

78' Tail naked, lightly haired, or heavily haired; cheek teeth prismatic, semiprismatic, or cuspidate with cusps of first two molars situated in two longitudinal rows 81

79 Body small (total length less than 250 mm) and mouse-like; upper incisors notched on occlusal surface ..... *Mus musculus*

79' Body larger (total length greater than 250 mm) and rat-like; upper incisors not notched on occlusal surface 80

80 Tail usually longer than head and body; first upper molar with distinct outer notches on first row of cusps ..... *Rattus rattus*
80' Tail shorter than head and body; first upper molar without distinct outer notches on first row of cusps ..... *Rattus norvegicus*

81 Tail laterally compressed; hind foot partially webbed; zygomatic plate not extending anteriorly from zygomatic process of maxilla; cheek teeth prismatic ..... *Ondatra zibethicus*
81' Tail round, not laterally compressed; hind foot not webbed at all; zygomatic plate extending anteriorly from zygomatic process of maxilla; cheek teeth semiprismatic or cuspidate 82

82 Body rat-like; size large (greatest length of skull greater than 38 mm); cheek teeth semiprismatic with deep re-entrant angles 83
82' Body mouse-like or rat-like; size smaller (greatest length of skull less than 38 mm); cheek teeth cuspidate 85

83 Dorsum steel gray ..... *Neotoma micropus*
83' Dorsum brownish or tan 84

84 Throat hairs white to base; anterointernal re-entrant angle of first upper molar shallow, not extending greater than half way across crown ..... *Neotoma albigula*
84' Hairs on throat often, but not always, gray at base; anterointernal re-entrant angle of first upper molar deep, extending greater than half way across crown ..... *Neotoma mexicana*

85 Body large, rat-like (total length greater than 220 mm); temporal ridge strongly developed; zygomatic notch deep 86
85' Body small, mouse-like (total length less than 220 mm); temporal ridge absent; zygomatic notch shallow 88

86 Under parts buffy to ochraceous; tail entirely black; top of feet buffy ..... *Sigmodon fulviventer*
86' Under parts whitish; tail bicolored, dark above and light below; top of feet whitish 87

87 Size smaller (total length less than 260 mm); area around nose yellowish or orange ..... *Sigmodon ochrognathus*
87' Size larger (total length greater than 260 mm); area around nose similar in color to rest of dorsum ..... *Sigmodon hispidus*

88 Upper incisor with distinct median groove on anterior surface 89
88' Upper incisor smooth, without distinct median groove on anterior surface 91

89 Bright fulvous coloration on sides; tail relatively long (greater than 80 mm and much longer than head and body), naked and scaly, and not bicolored; last lower molar with S-shaped dentine ..... *Reithrodontomys fulvescens*

89' Sides buffy to brown; tail shorter (less than 80 mm and usually shorter or about the same length as head and body), with short hairs, often bicolored; last lower molar with C-shaped dentine 90

90 Tail usually about equal length to head and body, not sharply bicolored; breadth of braincase greater than 9.6 mm ..... *Reithrodontomys megalotis*

90' Tail shorter than length of head and body, and sharply bicolored; breadth of braincase less than 9.6 mm ..... *Reithrodontomys montanus*

91 Tail relatively short (less than 60 percent head and body length); coronoid process extending well above condyloid process; soles of feet well-furred ..... *Onychomys arenicola*

91' Tail relatively long (greater than 60 percent head and body length); coronoid process not extending well above condyloid process; soles of feet only sparsely furred 92

92 Tail conspicuously shorter than head and body 93

92' Tail as long or longer than head and body 94

93 Total length usually greater than 170 mm (mean about 175 mm); tail usually greater than 75 mm , and not sharply bicolored ..... *Peromyscus leucopus*

93' Total length usually less than 170 mm (mean about 160 mm); tail usually less than 75 mm, and sharply bicolored ..... *Peromyscus maniculatus*

94 Tail scaly, almost naked; heel naked; only four mammae present in females (pectoral mammae absent); in males, glans penis broad, vase-shaped, and strongly flared distally; posterior extensions of premaxilla extending far beyond posterior end of nasal ..... *Peromyscus eremicus*

94' Tail heavily or scantly haired; heel furred; six mammae present in females; in males, glans penis elongate and rod-shaped; posterior extensions of premaxilla not extending far beyond posterior end of nasal 95

95 Tarsal joint of ankle white; ears small (usually less than 18 mm); baculum of males with long, cartilaginous spine at tip; tail only scantly haired with short tuft ..... *Peromyscus pectoralis*

95' Dusky color of hind leg extending to tarsal joint; ears larger (greater than 18 mm); baculum of males with short, cartilaginous spine at tip; tail more heavily haired with short longer tuft 96

96 Dorsal color bright yellow-brown; ears medium (usually less than 20 mm); greatest length of skull usually less than 28 mm ..... *Peromyscus boylii*

96' Dorsal color grayish; ears large (greater than 20 mm); greatest length of skull usually greater than 28 mm ..... *Peromyscus nasutus*

ACCOUNTS OF SPECIES

In the following accounts of species, detailed accounts of the native species of mammals are presented, followed by brief accounts of nondomestic introduced species, domestic species, and species of postulated occurrence. In addition, a fourth section on extirpated species provides general information on two species of mammals that once inhabited the BBRSP area, but now are absent from the area.

Within each section, accounts are presented in currently accepted phylogenetic order through genera (Jones and Jones, 1992; Jones et al., 1992). Species are arranged alphabetically within each genus. Unless noted, scientific and vernacular names follow those of Jones and Jones (1992), and Jones et al. (1992). All linear measurements presented are in millimeters. Weights are in grams unless noted, in which case they are in kg.

Native Species

For each of the 59 species of native mammals known to occur in BBRSP, the following are included: a description of the species, including key characteristics that help differentiate it from similar species; the overall distribution of the species, as well as locations within BBRSP from which it has been recorded; information regarding various aspects of the ecology and natural history of the species; additional comments pertaining to the taxonomy and nomenclature of taxa from BBRSP; and a list of specimens examined. The majority of the specimens examined are deposited in the Collection of Recent Mammals at the Museum of Texas Tech University and are not denoted with an acronym. A small number are housed in the mammal collection at Sul Ross State University and are indicated by the acronym SRSU.

Unless noted otherwise, all linear measurements refer to adults without regard to sex, and weights presented were taken from non-gravid adults. Refer to the Methods section for an explanation of relative abundance indices.

ORDER CHIROPTERA—BATS

Family Mormoopidae (Mormoopid Bats)

Mormoops megalophylla (Peters, 1864)
Ghost-faced Bat

Description.—*Mormoops megalophylla* is a medium-sized bat with dorsal pelage that ranges from pale brown to reddish-brown. Constantine (1958) attributed this variation to the fading of adult pelage. A reddish tinge in the hairs indicates an older pelage (Smith, 1972). The ears of the ghost-faced bat are round and fused across the rostrum. The tragus is complex and folded. A distinct leaf-like structure is present on the chin, and the tail protrudes dorsally from the middle of the uropatagium. The skull of *M. megalophylla* is unique in that the braincase is grossly vaulted, rising abruptly above an upturned rostrum. The dental formula for this species is: i 2/2, c 1/1, p 2/3, m 3/3, total 34.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult female specimens from BBRSP are: total length, 89.3 (119, 79-108, 3.9); length of tail vertebrae, 28.8 (113, 24-32, 1.5); length of hind foot, 10.0 (120, 8-13, 0.8); length of ear from notch, 13.9 (120, 13-17, 0.9); weight, 15.1 (90, 11.5-18.0, 1.4); greatest length of skull, 14.12 (20, 13.86-14.80, 0.23). Females average slightly larger than males (Rezsutek and Cameron, 1993).

Ghost-faced bats are easily distinguished from all other species of bats that occur in BBRSP. No other species in the park possesses a chin leaf or a tail that protrudes dorsally from the tail membrane.

Distribution.— *M. megalophylla* ranges from parts of northern South America, northward through Central America, on up to northern Mexico and the southern United States. In the United States, it is known only from southern Arizona and Texas (Rezsutek and

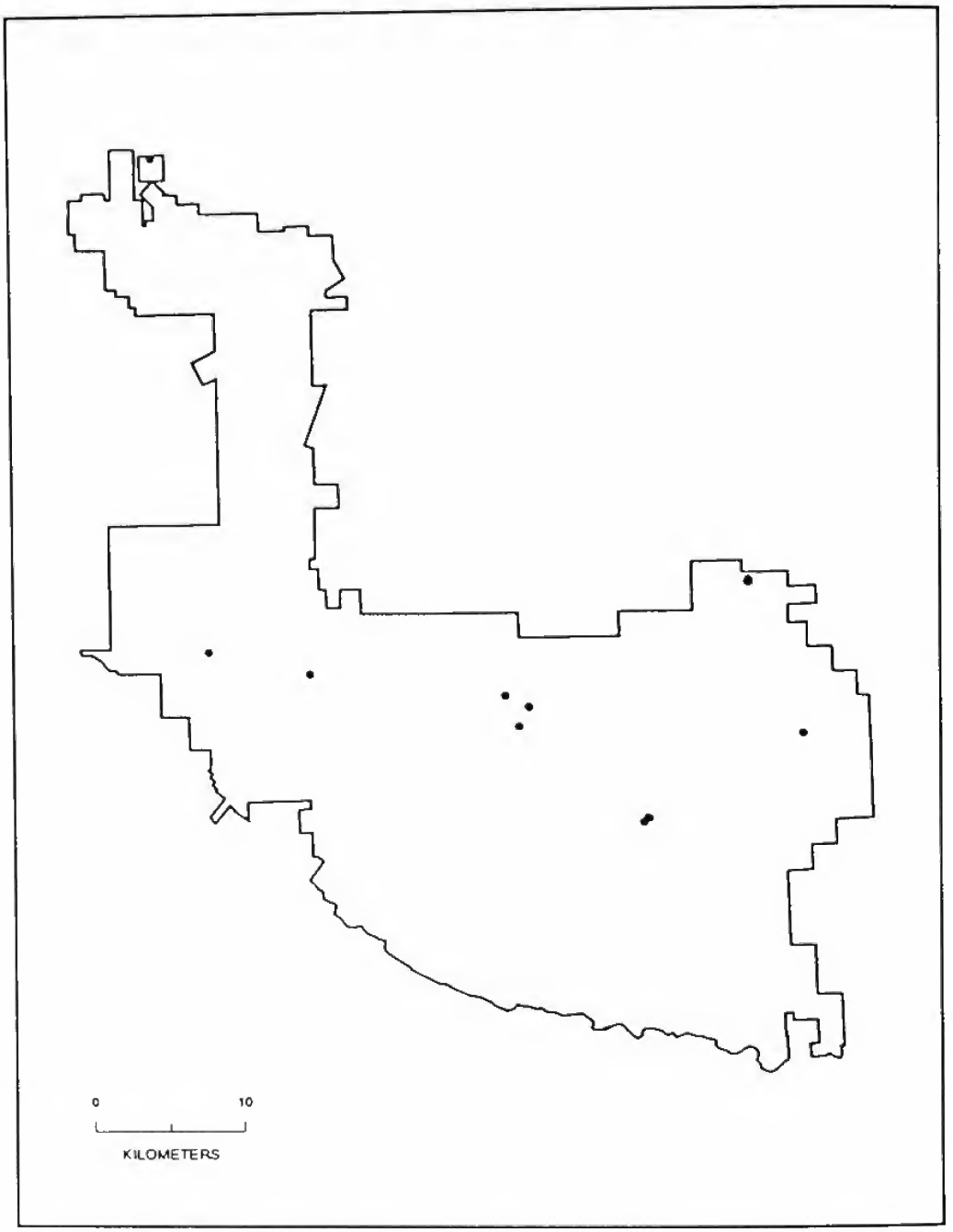

Figure 10. Localities of known specimens of *Mormoops megalophylla* from Big Bend Ranch State Park, Texas.

Cameron, 1993). At BBRSP, the ghost-faced bat was recorded throughout the park (Fig. 10), but was most often found in the Los Alamos, Arroyo Segundo, and Las Quevas areas.

Natural History.— With a relative abundance index of 0.389, *M. megalophylla* was the second most frequently encountered bat at BBRSP. This species accounted for 23 percent of all bats collected. Only western pipistrelles (*Pipistrellus hesperus*) were more common. Scudday (1976*b*) reported ghost-face bats as rare from the area. This discrepancy indicates the possible existence of temporal variations in the population size of this species at BBRSP.

All specimens of *M. megalophylla* were acquired from water-associated habitats. This species occasionally was taken in riparian areas with dense vegetation that formed a closed canopy, but was acquired more often from areas near streams and springs that were not enclosed by thick vegetation. Individuals were taken from both deep and shallow canyons, as well as areas of level topography, but the species seemed to favor canyons to flatlands. This bat is known to roost in caves (Schmidly, 1991), and the abundance of these structures on the sides of canyon walls probably accounts for this bat's affinity for canyons.

Ghost-faced bats are known to reside in Trans-Pecos Texas only during the spring and summer (Schmidly, 1991). I found this to be the situation at BBRSP, as this bat was taken only between 29 April and 18 September. Of 130 adult individuals captured, all were females. Interestingly, this species winters on the Edwards Plateau just to the east. No seasonal migration between the two regions has been documented (Schmidly, 1991).

Information available on the reproductive biology of *M. megalophylla* is scant. In Big Bend National Park, Easterla (1973) discovered two gravid females on 15 June, each of which possessed one embryo. I examined 30 pregnant females taken from 29 April to 9 June, all of which contained only a single embryo as well. Pregnant females (corresponding crown-rump length of embryos in parentheses) were examined on the following dates: 29 April (17, 20, 21), 30 April (18, 20 21, 22), 2 May (19, 22), 14 May (22, 23, 24), 15 May (28), 16 May (22), 20 May (25, 26), 24 May (19, 24, 27), 28 May (26), 29 May (26, 28), 30 May (21), 6 June (27), and 9 June (26). Lactating females were noted from 21 June to 18 September. One volant juvenile individual, a male, was captured on 3 September. The aforementioned reproductive data suggest that female ghost-faced bats migrate to BBRSP in the spring to set up nursery colonies. They are well into their pregnancy upon arrival, and give birth to a single young probably in early to mid-June. Nursing appears to continue for at least three months, a duration among the highest known in bats (Hill and Smith, 1984). Young continue to suckle well after the ability of flight is obtained, and possibly into the onset of fall migration.

M. megalophylla was active from just after dusk (2154 h) to just after sunrise (0700 h), but was observed most often between 2200 h and midnight. Foraging occurred above standing or slowly moving water. This bat previously has been reported to feed strictly on lepidopterans, however this conclusion was based on the evaluation of gastrointestinal contents of only four individuals (Easterla and Whitaker, 1972). I examined the contents of 45 stomachs, and found that *M. megalophylla* favors lepidopterans (100 percent occurrence), but occasionally feeds on coleopterans (4.4 percent occurrence), homopterans (2.2 percent occurrence), hemipterans (2.2 percent occurrence), and neuropterans (2.2 percent occurrence).

Other species of bats taken from the same localities at BBRSP as *M. megalophylla* included *Myotis californicus*, *M. thysanodes*, *M. velifer*, *M. yumanensis*, *Pipistrellus hesperus*, *Eptesicus fuscus*, *Plecotus townsendii*, *Antrozous pallidus*, *Tadarida brasiliensis*, and *Nyctinomops macrotis*.

Ectoparasites found on ghost-faced bats from BBRSP included ticks and streblid flies. Ectoparasites previously reported from this bat include two species of streblid flies (Whitaker and Easterla, 1975; Whitaker et al., 1987), chiggers (Jameson, 1959; Loomis, 1969), and wing mites (Jameson, 1959). Internal parasites collected included two unidentified cestodes and an undetermined species of nematode. In addition, Jameson (1959) documented the presence of trematodes in the small intestine of *M. megalophylla*. In Mexico, populations of this bat are known to be afflicted by large-scale outbreaks of rabies (Jimenez Guzman, 1982). However, 42 specimens from BBRSP were tested for the rabies virus, and all proved to be negative (Yancey et al., 1997).

Comments.— The subspecies of *M. megalophylla* at BBRSP is *M. m. megalophylla* (Peters, 1864). The generic name *Mormoops* is derived from the Greek "mormon" and "ops," which translate to she-monster and face, respectively. The specific epithet *megalophylla* is from the Greek "megas" and "phyllon," meaning big and leaf, respectively (Stangl et al., 1993).

Specimens Examined (126).— Presidio Co.: BBRSP, UTM coordinates: 13 576699E 3296276N, 1; BBRSP, UTM coordinates: 13 580196E 3264339N, 2; BBRSP, UTM coordinates: 13 586937E 3262923N, 26; BBRSP, UTM coordinates: 13 586938E 3262910N, 4; BBRSP, UTM coordinates: 13 599794 E 3261524N, 1; BBRSP, UTM coordinates: 13 600689E 3259514N, 1; BBRSP, UTM coordinates: 13 601325E 3260789N, 4; BBRSP, UTM coordinates: 13 601335E 3260787N, 2; BBRSP, UTM coordinates: 13 608608E 3253227N, 7; BBRSP, UTM coordinates: 13 608870E 3253520N, 2; BBRSP, UTM coordinates: 13 608955E 3253483N, 3; BBRSP, UTM coordinates: 13 615458E 3268807N, 1; BBRSP, UTM coordinates: 13 615525E 3268958N, 18; BBRSP, UTM coordinates: 13 615559E 3268762N, 1; BBRSP, UTM coordinates: 13 615565E 3268878N, 21; BBRSP, UTM coordinates: 13 615599E 3268863N, 29; Fresno Canyon, Smith Ranch, 2 (SRSU). Brewster Co.: El Solitario, Tres Papalotes, 1 (SRSU).

Family Vespertilionidae (Vespertilionid Bats)

Myotis californicus (Audubon and Bachman, 1842)
California Myotis

Description.—*Myotis californicus* is a small bat with pale brown to reddish-brown dorsal pelage. It possesses a dark facial mask that extends from ear to ear. The calcar of this bat is keeled, and its feet are small. The dental formula for *M. californicus* is: i 2/3, c 1/1, p 3/3, m 3/3, total 38.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of specimens from BBRSP are: total length, 82.5 (20, 77-90, 3.8); length of tail vertebrae, 40.0 (20, 30-43, 3.0); length of hind foot, 6.1 (20, 5-7, 0.6); length of ear from notch, 13.6 (20, 12-15, 0.7); weight, 3.9 (17, 3.0-5.6, 0.6); greatest length of skull, 13.63 (20, 13.28-13.90, 0.18). No significant sexual dimorphism is apparent in *M. californicus* (Bogan, 1974).

M. californicus is confused easily with *M. ciliolabrum*. The former often takes on a more reddish color, whereas the latter usually is buff-brown in color. However, distinctions based solely on pelage color are unreliable. Only by close examination of the skull can these two species be separated. *M. californicus* has a braincase that rises abruptly above the rostrum, whereas that of *M. ciliolabrum* has a more flattened profile. Bivariate plots of depth of cranium versus rostral breadth may distinguish the two species (Bogan, 1974). *M. californicus* can be differentiated from other species of *Myotis* known from BBRSP and from *Pipistrellus subflavus* by the presence of the well-developed keel on its calcar. The only other bat at BBRSP that *M. californicus* might be mistaken for is *Pipistrellus hesperus*. However, these two species are distinguished easily based on tragus morphology. *M. californicus* has a long, straight, pointed tragus, whereas the tragus of *P. hesperus* is short, curved, and blunt.

Distribution.— *M. californicus* ranges from southern Mexico, northward through the southwestern United States and California, on up through the Pacific Northwest to the Alaskan Panhandle (Simpson, 1993). In BBRSP, it is known from the Las Quevas, Sauceda, Los Alamos, and Arroyo Segundo areas (Fig. 11).

Natural History.— With a relative abundance index of 0.062, *M. californicus* ranked sixth in captures among bats at BBRSP. It accounted for 3.7 percent of all bats netted. These figures suggest that this bat is neither common nor rare in the park.

All specimens of *M. californicus* taken during this study were acquired from riparian areas associated with creeks or springs. This species was taken in both dense, closed canopy vegetation, and open, sparsely vegetated areas. In the Trans-Pecos, *M. californicus* also has been recorded from desert scrub and grassland (Schmidly, 1991), and should be considered a potential resident of these habitats in BBRSP. This bat roosts alone or in small groups in rocky crevices, under tree bark, among small desert shrubs, on the ground, or in human structures (Krutzsch, 1954; Hirshfeld et al., 1977), all of which are abundant in BBRSP.

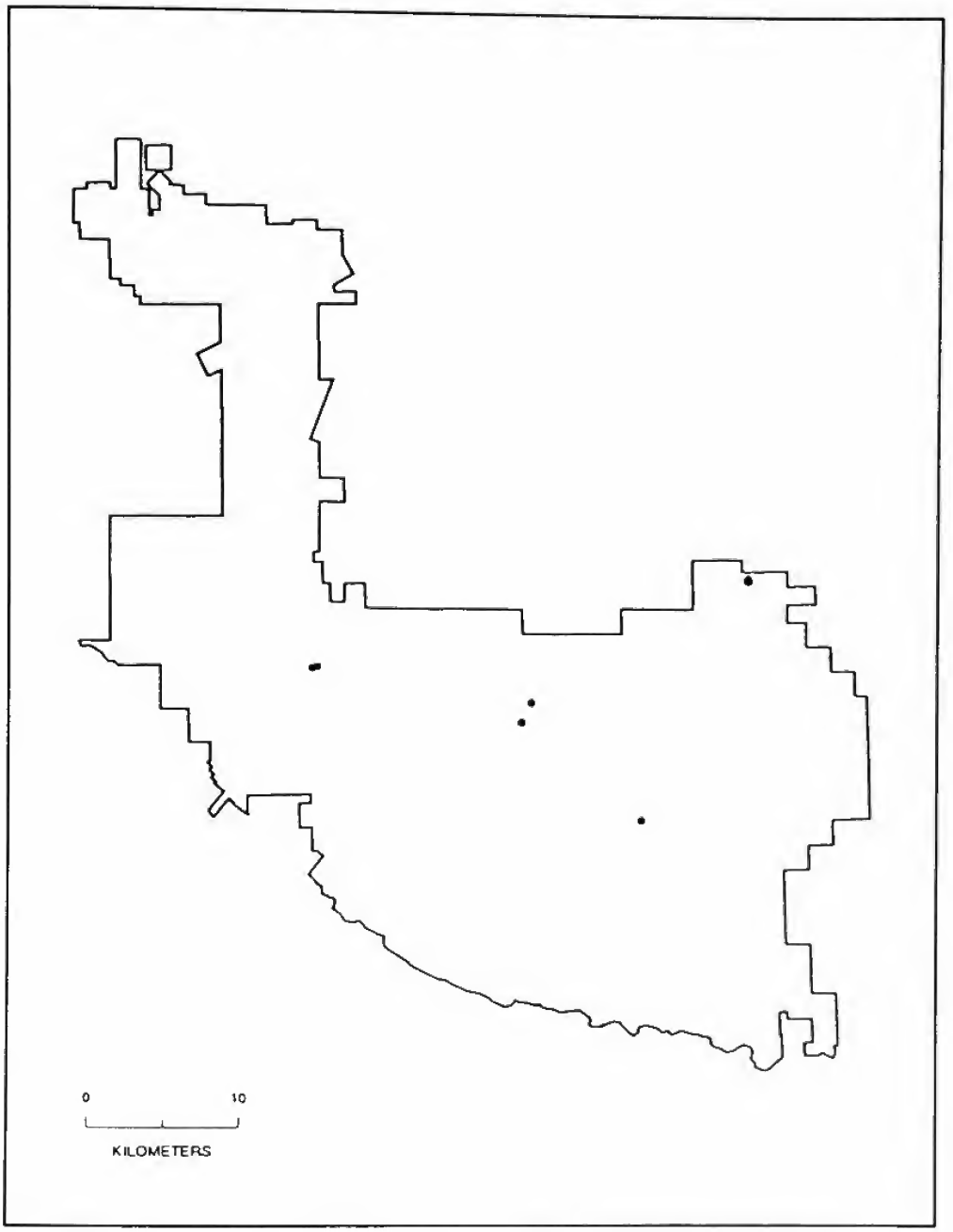

Figure 11. Localities of known specimens of *Myotis californicus* from Big Bend Ranch State Park, Texas.

M. californicus was recorded at BBRSP only from May to August. However, Schmidly (1991) suggests that this species overwinters in the Trans-Pecos, at which time it is known to be active. Furthermore, at Big Bend National Park this species was acquired on 3 March and 7 December (Easterla, 1973). Therefore, it should be considered a potential year round resident of BBRSP.

Over most of its range, the California myotis breeds in late autumn, at which time fertilization is delayed (Krutzsch, 1954). Of the 20 adult individuals of this species captured in BBRSP, 17 were females. This discrepancy probably is in response to the formation of maternity colonies in the area as reported for the species by Krutzsch (1954). Three gravid females, each of which contained a single embryo (corresponding

crown-rump length of embryos in parentheses), were noted on 29 May (11, 16) and 4 June (17). Lactating females were examined on 6, 7, and 9 June; 15 and 25 July; and 2 and 3 August. A single, volant juvenile was taken on 3 August. These data support a parturition period of late May to early June as reported by Schmidly (1991).

M. californicus often forages among trees and over water (Woodsworth, 1981). It is known to feed primarily on lepidopterans, dipterans (Whitaker et al., 1981), and trichopterans (Woodsworth, 1981), but also, to a lesser degree, on coleopterans and hemipterans (Woodsworth, 1981; Whitaker et al., 1981).

Other species of bats taken from the same localities at BBRSP as *M. californicus* were *Mormoops megalophylla*, *Myotis thysanodes*, *M. velifer*, *Pipistrellus hesperus*, *Eptesicus fuscus*, *Plecotus townsendii*, *Antrozous pallidus*, and *Tadarida brasiliensis*.

No parasites were noted in association with specimens of *M. californicus* from BBRSP. This bat is known to harbor various mites (Krutzsch, 1954; Dooley et al., 1976). The California myotis has been known to be afflicted with rabies (Constantine, 1986; 1988), but of eight individuals from BBRSP examined for the virus, all tested negative (Yancey et al., 1997).

Comments.— The subspecies of *M. californicus* at BBRSP is *M. c. californicus* (Audubon and Bachman, 1842). The generic name *Myotis* is derived from the Greek "mys" and "ous," which translate to mouse and ear, respectively. The specific epithet *californicus* refers to of California (Stangl et al., 1993).

Specimens Examined (21).— Presidio Co.: BBRSP, UTM coordinates: 13 586937E 3262923N, 1; BBRSP, UTM coordinates: 13 587263E 3263005N, 1; BBRSP, UTM coordinates: 13 600689E 3259514N, 1; BBRSP, UTM coordinates: 13 601325E 3260789N, 6; BBRSP, UTM coordinates: 13 608477E 3253180N, 1; BBRSP, UTM coordinates: 13 615458E 3268807N, 2; BBRSP, UTM coordinates: 13 615525E 3268958N, 1; BBRSP, UTM coordinates: 13 615559E 3268762N, 6; BBRSP, UTM coordinates: 13 615599E 3268863N, 2.

Myotis ciliolabrum (Merriam, 1886)
Western Small-footed Myotis

Description.— *Myotis ciliolabrum* is a small bat with pale brown pelage. A dark facial mask about the eyes and rostrum is present. This bat has a keeled calcar and relatively small feet. The dental formula for *M. ciliolabrum* is: i 2/3, c 1/1, p 3/3, m 3/3, total 38.

External and cranial measurements of a single adult female from BBRSP are: total length, 83; length of tail vertebrae, 42; length of hind foot, 6; length of ear from notch, 14; weight, 4.4; greatest length of skull, 13.82. No marked sexual dimorphism is evident in *M. ciliolabrum* (Bogan, 1974).

M. ciliolabrum often is confused with *M. californicus*. See the previous account for discriminating characters. *M. ciliolabrum* is distinguished easily from other species of *Myotis* known from BBRSP and from *Pipistrellus subflavus* by its keeled calcar. Superficially, *M. ciliolabrum* might be confused with *Pipistrellus hesperus*. However, the two can be readily distinguished based on the appearance of the tragus. *M. ciliolabrum* has a long, straight, pointed tragus, whereas the tragus of *P. hesperus* is short, curved, and blunt.

Distribution.— *M. ciliolabrum* ranges from central Mexico, northward throughout the western half of the United States, and into southwestern Canada (Jones and Birney, 1988). In BBRSP, it is known from only a single specimen taken from Lava Canyon (Fig. 12).

Natural History.— With a relative abundance index of 0.003, *M. ciliolabrum* was among the rarest of bats encountered at BBRSP. This species accounted for only 0.2 percent of all bats captured. *M. ciliolabrum* also was reported as rare in neighboring Big Bend National Park (Easterla, 1973).

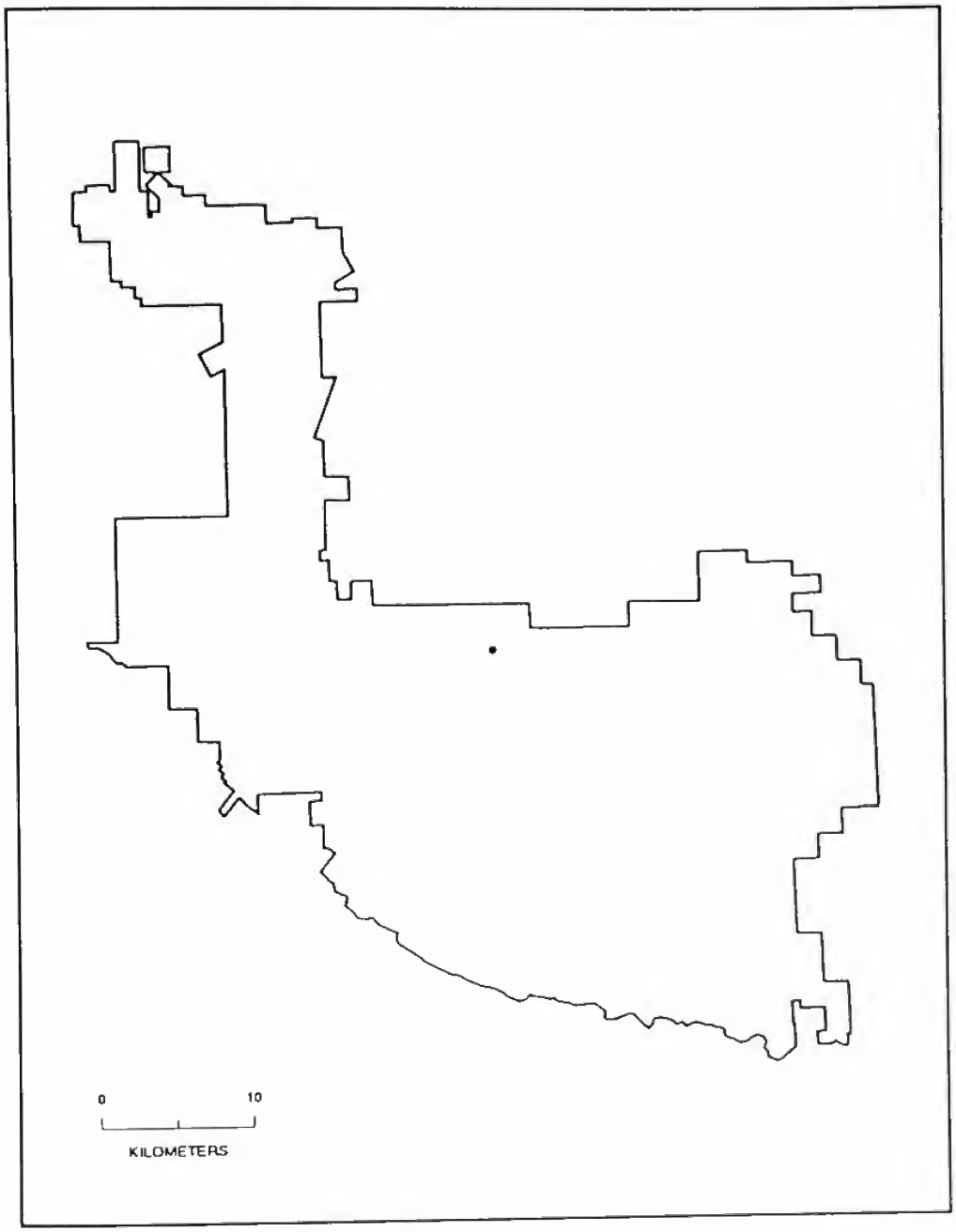

Figure 12. Localities of known specimens of *Myotis ciliolabrum* from Big Bend Ranch State Park, Texas.

The individual taken in BBRSP was netted over a small pool in a shallow canyon. Vegetation at the site was sparse. Although occasionally recorded from desert areas in the Trans-Pecos, *M. ciliolabrum* favors wooded, mountainous areas, which are uncommon in BBRSP. Preferred roosting sites of *M. ciliolabrum* include rock crevices, under loose tree bark, and in man-made structures (Schmidly, 1991), all of which are abundant at BBRSP. Therefore, it is probably this species' ecological affinity for montane habitats that accounts for its scarcity in the park.

The single western small-footed myotis collected during this study was taken in July. The species has been documented to occur in the Trans-Pecos only from

March through July. However, in much of the remainder of its range it is thought to hibernate within its summer range (Schmidly, 1991). Therefore, *M. ciliolabrum* may occur in BBRSP throughout the year.

Little is known regarding the reproductive biology of *M. ciliolabrum*. Schmidly (1991) reports that this species forms small maternity colonies, where birth is given to a single young from late May to early June. The one individual from BBRSP was a non-gravid, nonlactating, adult female taken on 21 July.

M. ciliolabrum often forages near rocky bluffs or, in the absence of its close congener *M. californicus*, over water (Woodsworth, 1981). The specimen from BBRSP was taken while foraging near rocky bluffs and over water. The kinds of prey that *M. ciliolabrum* forages upon are not documented, but Black (1974) suggests that it favors either lepidopterans or coleopterans.

Other species of bats taken from the same locality at BBRSP as *M. ciliolabrum* included *Pipistrellus hesperus* and *Antrozous pallidus*.

The one specimen of *M. ciliolabrum* from BBRSP tested negative for rabies (Yancey et al., 1997). However, the species is known to harbor the virus (Constantine, 1988).

Comments.— The subspecies of *M. ciliolabrum* at BBRSP is *M. c. ciliolabrum* (Merriam, 1886). Previously, *M. ciliolabrum* was considered a subspecies of *M. leibii*, the eastern small-footed myotis, until the former was elevated to specific status by Van Zyll de Jong (1984). See the account on *Myotis californicus* for the etymology of the generic name. The specific epithet *ciliolabrum* is from the Latin "cilium" and "labrum," meaning eyelid and lip, respectively (Stangl et al., 1993).

Specimens Examined (1).— Presidio Co.: BBRSP, UTM coordinates: 13 598236E 3263889N, 1.

Myotis thysanodes G. S. Miller, 1897
Fringed Myotis

Description.— *Myotis thysanodes* is a medium-sized bat with a buffy-brown dorsal pelage. An obvious fringe of short, stiff hairs extends from the trailing edge of the uropatagium. Its calcar is without a keel, and relative to other species of *Myotis* at BBRSP, its feet and ears are large. The dental formula for *M. thysanodes* is: i 2/3, c 1/1, p 3/3, m 3/3, total 38.

External and cranial measurements of one adult male and one adult female, respectively, from BBRSP are: total length, 85, 90; length of tail vertebrae, 37, 35; length of hind foot, 9, 9; length of ear from notch, 17, 17; weight, 6.7, 10 (gravid); greatest length of skull, 16.61, 16.32. Females tend to be larger than males (Williams and Findley, 1979).

Superficially, *M. thysanodes* may appear similar to other species of bats at BBRSP. However, the presence of the fringe of short hairs on the free edge of the uropatagium easily discriminates this bat from all others at the park.

Distribution.— *M. thysanodes* ranges from southern Mexico, through the southwestern United States to the Pacific Northwest, and into southern British Columbia (O'Farrell and Studier, 1980). In BBRSP, it is known only from the Sauceda area and Arroyo Segundo (Fig. 13).

Natural History.— During this study, only two specimens of *M. thysanodes* were taken, which resulted in a relative abundance of 0.006. This species accounted for only 0.4 percent of all bats taken, and therefore should be considered rare in BBRSP. Easterla (1973) reported that, except for nursery colonies, the fringed myotis was uncommon at Big Bend National Park as well.

Both specimens of *M. thysanodes* taken during this study were captured while flying over small pools of water in deep or shallow canyons. In addition, this

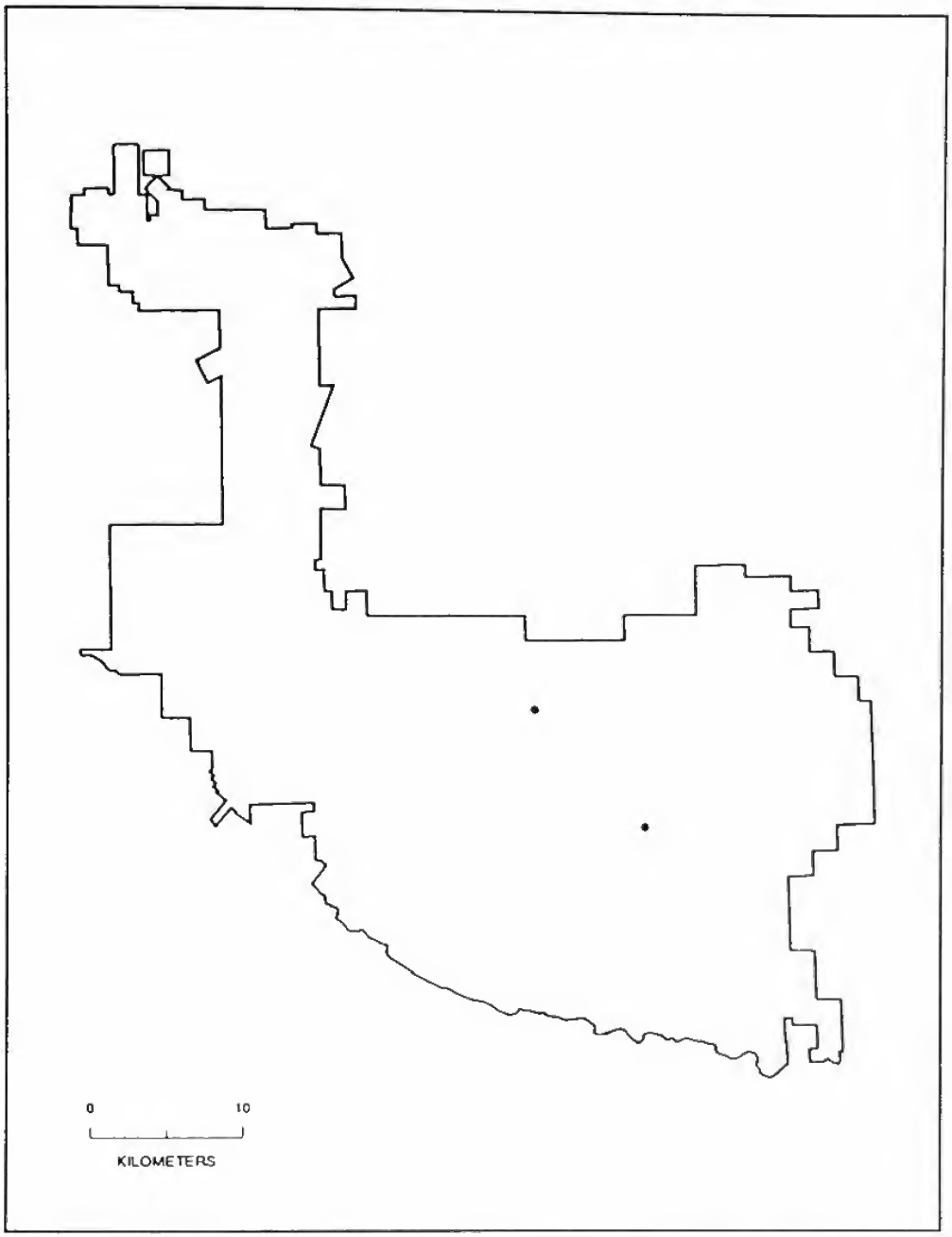

Figure 13. Localities of known specimens of *Myotis thysanodes* from Big Bend Ranch State Park, Texas.

bat may be found in montane woodlands, desert scrub, and grassy areas. The fringed myotis utilizes caves, tunnels, rock crevices, and human structures as roosts (Schmidly, 1991).

M. thysanodes was recorded in BBRSP only in June and July. It is a migratory bat that arrives in the area in May. Its winter grounds and behavior are unknown (Schmidly, 1991).

The reproductive biology of *M. thysanodes* is not well understood. Upon arrival to the Trans-Pecos in May, females form nursery colonies (Schmidly, 1991). O'Farrell and Studier (1973) report that females give

birth during the last week of June or the first week of July. However, a near-term pregnant female (crown-rump length, 21) that I examined on 9 June suggests that parturition at BBRSP may occur earlier. Nursery colonies at Big Bend National Park apparently disperse in October (Easterla, 1973).

Black (1974) lists *M. thysanodes* as a bat that forages between, within, or below vegetative canopy. However, vegetation was sparse in both areas from which I collected this species. The fringed myotis is known to consume primarily coleopterans, but also feeds on lepidopterans to a lesser degree (Black, 1974).

Other species of bats taken in sympatry with *M. thysanodes* included *Mormoops megalophylla*, *Myotis californicus*, *Pipistrellus hesperus*, *Eptesicus fuscus*, *Plecotus townsendii*, *Antrozous pallidus*, and *Tadarida brasiliensis*.

An unidentified species of tick was noted on *M. thysanodes* from BBRSP. In a summary of the ectoparasites of *M. thysanodes*, O'Farrell and Studier (1980) list several species of mites and a wingless fly. Cestodes are the only endoparasites reported from *M. thysanodes* (Cain and Studier, 1974). Constantine (1988) reported this bat as a host of the rabies virus. A single individual from BBRSP was tested for rabies; it proved to be negative (Yancey et al., 1997).

Comments.— The subspecies of *M. thysanodes* that occurs at BBRSP is *M. t. thysanodes* Miller, 1897. See the account on *Myotis californicus* for the etymology of the generic name. The specific epithet *thysanodes* is from the Greek "thysanos" and "odes," meaning tassel or fringe, and resemblance, respectively (Stangl et al., 1993).

Specimens Examined (2).— Presidio Co.: BBRSP, UTM coordinates: 13 601325E 3260798N, 1; BBRSP, UTM coordinates: 13 608477E 3253180N, 1.

Myotis velifer (J. A. Allen, 1890)
Cave Myotis

Description.— *Myotis velifer* is a medium-sized bat with a dull, grayish-brown dorsal pelage. The calcar of this species lacks a keel. Its feet are large, and its ears are intermediate in length. A bare patch in the pelage near the interscapular region frequently is present. A well-developed sagittal crest is present on the cranium. The dental formula for *M. velifer* is: i 2/3, c 1/1, p 3/3, m 3/3, total 38.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of specimens from BBRSP are: total length, 96.8 (15, 89-115, 6.6); length of tail vertebrae, 40.3 (15, 35-46, 3.4); length of hind foot, 9.1 (15, 8-10, 0.7); length of ear from notch, 15.4 (15, 14-16, 0.8); weight, 8.3 (15, 6.0-10, 1.2); greatest length of skull, 16.27 (7, 15.83-16.53, 0.26). Females are significantly larger than males for some measurements (Williams and Findley, 1979).

M. velifer conceivably could be mistaken for *M. thysanodes*, but the former lacks the obvious fringe of hairs on the posterior margin of the uropatagium. *M. velifer* is easily distinguished from all other species of bats known to occur at BBRSP.

Distribution.— *M. velifer* ranges from Central America, northward through Mexico, and into the southwestern United States. A disjunct population occurs on the southern High Plains of the United States (Fitch et al., 1981). At BBRSP, this bat was found along Cienega Creek and near Los Alamos (Fig. 14).

Natural History.— *M. velifer* had a relative abundance index of 0.036, which ranked sixth among bats at BBRSP. This species represented 2.6 percent of all bats netted. These results suggest that the cave myotis is not extremely common in BBRSP. It was reported as uncommon at Big Bend National Park (Easterla, 1973).

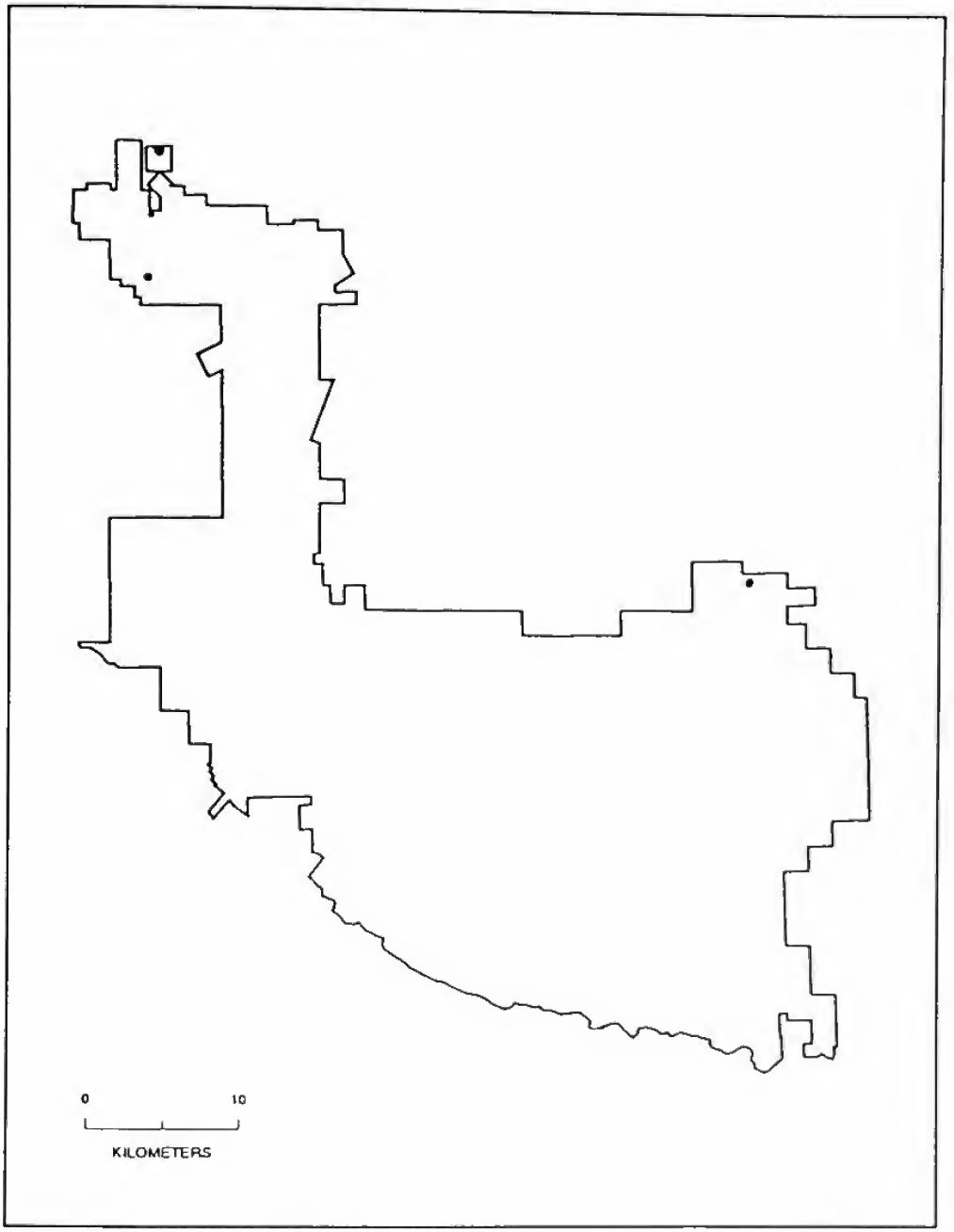

Figure 14. Localities of known specimens of *Myotis velifer* from Big Bend Ranch State Park, Texas.

M. velifer was taken mostly along watercourses in areas of thick vegetation, but also near human dwellings. It tends to roost in caves and tunnels (Schmidly, 1991), often in colonies of 2000 to 5000 individuals (Fitch et al., 1981).

The cave myotis is reported as a year round resident of the Texas Panhandle and the Edwards Plateau, but, prior to this work at BBRSP, was unknown from the Trans-Pecos during the winter months. *M. velifer* was taken at BBRSP from 29 May to 5 September, and a single individual was acquired on 26 February. This specimen represents the first winter record of the cave myotis from Trans-Pecos Texas (Yancey and Jones, 1996). This winter specimen indicates that at least part of the Trans-Pecos population of *M. velifer* winters in the region. Most individuals of *M. velifer* in the area

probably migrate from the region to winter hibernacula elsewhere. But a few individuals apparently hibernate in local caves over the winter, occasionally taking flight for short periods of time, as is the case with *M. velifer* from the Panhandle (Schmidly 1977*a*).

Information on the reproductive biology of *M. velifer* in the Trans-Pecos is sparse (Schmidly, 1977*a*). Copulation probably occurs in the fall and winter (Fitch et al., 1981). Females are reported to give birth to a single young (Schmidly, 1991). I examined no pregnant females during this study, and there are no prior records of gravid females from the Trans-Pecos (Schmidly, 1977*a*). In Kansas, Kunz (1973*a*) found that the cave myotis gives birth at the end of June or beginning of July. However, in central Texas, Raun and Baker (1958) noted near-term gravid females in May. The latter report led Easterla (1973) to speculate that parturition in *M. velifer* in the Big Bend region occurs in May. I examined lactating females on 5 July, and in Big Bend National Park, Easterla (1973) noted lactating females from 15 June to 26 July.

During the summer, *M. velifer* usually forages two times during the night (Kunz, 1974). At BBRSP, this species frequently was observed feeding shortly after sunset. Kunz (1974) reports a second foraging period occurs just prior to sunrise. This bat is an opportunistic insectivore with a fluctuating diet (Fitch et al., 1981). It is known to prey heavily on small lepidopterans (Ross, 1967; Hayward, 1970) and coleopterans (Kunz, 1974).

Other species of bats found in association with *M. velifer* at BBRSP included *Mormoops megalophylla*, *Myotis californicus*, *M. yumanensis*, *Pipistrellus hesperus*, *Eptesicus fuscus*, *Lasiurus cinereus*, *Plecotus townsendii*, *Antrozous pallidus*, and *Tadarida brasiliensis*.

No parasites were observed in association with specimens of *M. velifer* at BBRSP. Ectoparasites known to infest *M. velifer* include mites (Fitch et al., 1981), true bugs (Bradshaw and Ross, 1961), fleas (Jameson, 1959; Bradshaw and Ross, 1961; Ubelaker, 1966; Reisen et al., 1976), and flies (Jameson, 1959; Ubelaker, 1966; Hayward, 1970; Reisen et al., 1976). Endoparasites known from *M. velifer* include various species of trematodes, cestodes, and nematodes (Fitch et al., 1981). Rabies has been reported to infect the cave myotis (Constantine, 1988; Schmidly, 1991). Schmidly (1991) reports that only two of 82 (2.4 percent) specimens submitted to the Texas Department of Health tested positive. Four specimens from BBRSP were examine for rabies; all tested negative (Yancey et al., 1997).

Comments.— The subspecies of *M. velifer* that occurs at BBRSP is *M. v. incautus* (J. A. Allen, 1896). See the account on *Myotis californicus* for the etymology of the generic name. The specific epithet *velifer* is from the Latin "velum" and "ferre," meaning sail, and carry, respectively (Stangl et al., 1993).

Specimens Examined (15).— Presidio Co.: BBRSP, UTM coordinates: 13 576060E 3288074N, 1; BBRSP, UTM coordinates: 13 576699E 3296276N, 1; BBRSP, UTM coordinates: 13 576783E 3296292N, 5; BBRSP, UTM coordinates: 13 576795E 3296125N, 3; BBRSP, UTM coordinates: 13 576823E 3296177N, 2; BBRSP, UTM coordinates: 13 576842E 3296279N, 1; BBRSP, UTM coordinates: 13 615559E 3268762N, 1; BBRSP, UTM coordinates: 13 615599E 3268863N, 1.

Myotis yumanensis (H. Allen, 1864)
Yuma Myotis

Description.— *Myotis yumanensis* is a small bat with pale to buff-brown dorsal pelage. Its calcar lacks a keel, its ears are small, and its feet are relatively moderate in size. The dental formula for *M. yumanensis* is: i 2/3, c 1/1, p 3/3, m 3/3, total 38.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of specimens from BBRSP are: total length, 77.3 (4, 73-80, 3.1); length of tail vertebrae, 33.8 (4, 28-37, 4.0); length of hind foot, 7.8 (4, 7-8, 0.5); length of ear from notch, 13.8 (4, 13-14, 0.5); weight, 4.8 (4, 4.3-5.5, 0.6); greatest length of skull, 13.20 (4, 13.04-

13.37, 0.15). I know of no reports pertaining to secondary sexual dimorphism in this species.

Of the species of bats known from BBRSP, *M. yumanensis* is most easily confused with *M. californicus*, *M. ciliolabrum*, and *Pipistrellus hesperus*. *M. yumanensis* is distinguished easily from all three of these bats by the absence of a keel on its calcar. In addition, the tragus of *P. hesperus* is short and blunt, whereas it is long and pointed in all members of the genus *Myotis*.

Distribution.— *M. yumanensis* ranges from central Mexico, northward through the southwestern United States, up through California and the Pacific Northwest, thence into British Columbia (Hall, 1981). In BBRSP, it is known from the Cienega Mountains area, Arroyo Segundo, the Whitroy Mine area, and along the Rio Grande (Fig. 15).

Natural History.— With a relative abundance index of 0.006, and comprising only 0.4 percent of all bats netted, *M. yumanensis* appears to be rather rare at BBRSP. However, in addition to individuals netted, others were acquired from roost sites. Furthermore, several more individuals were taken or sighted in areas outside, but adjacent to, BBRSP. Therefore, this bat should be considered more common than mist net results suggest, especially along the Rio Grande Corridor.

M. yumanensis is known to occur in both upland and lowland situations, but seems to prefer the latter (Schmidly, 1977*a*). Only two specimens of *M. yumanensis* were netted during this study. Both were taken in riparian areas associated with cottonwood and willow trees. One was from a deep canyon in an area of sparse vegetation, whereas the other was taken on level terrain in thick, closed-canopy vegetation. Additional individuals were taken from their daytime roost, which was an abandoned building near Whitroy Mine.This structure is situated in desert scrub dominated by creosote-bush. Outside BBRSP near Lajitas, *M. yumanensis* was netted above open water along the Rio Grande. Night roost structures of this bat included the undersides of the structures at Teepees Roadside Park, and Madera Creek Bridge on FM 170. In addition to buildings and bridges, these bats also may roost in caves and mine tunnels (Schmidly, 1991).

M. yumanensis was detected in BBRSP between 23 June and 17 August, but the species is known to occur in the Trans-Pecos from April through November. Furthermore, there is speculation that this bat may hibernate in the area over the winter (Schmidly, 1977*a*). Therefore, *M. yumanensis* should be considered a potential year round resident of BBRSP.

Prior to parturition, females form large nursery colonies (Schmidly, 1991). No gravid or lactating females were examined during this study, but in Big Bend National Park, a single young reportedly is born in late May or early June, and lactating females were observed between 10 June and 12 July. Volant juveniles were noted in Big Bend National Park as early as 28 June (Easterla, 1973).

M. yumanensis most often forages at low levels over streams and ponds (Schmidly, 1991). It is known to feed on a variety of insects, but appears to favor lepidopterans, dipterans, and coleopterans (Easterla, 1973).

Other species of bats found at the same localities as *M. yumanensis* at BBRSP included *Mormoops megalophylla*, *Myotis velifer*, *Pipistrellus hesperus*, *Eptesicus fuscus*, *Plecotus townsendii*, *Antrozous pallidus*, *Tadarida brasiliensis*, and *Nyctinomops macrotis*.

No parasites were observed in association with *M. yumanensis* during this study. This bat is known to be afflicted by the rabies virus (Constantine, 1988). Only a single individual from BBRSP was tested for the virus and it was negative (Yancey et al., 1997).

Comments.— The subspecies of *M. yumanensis* that occurs at BBRSP is *M. y. yumanensis* (H. Allen, 1864). See the account on *Myotis californicus* for the

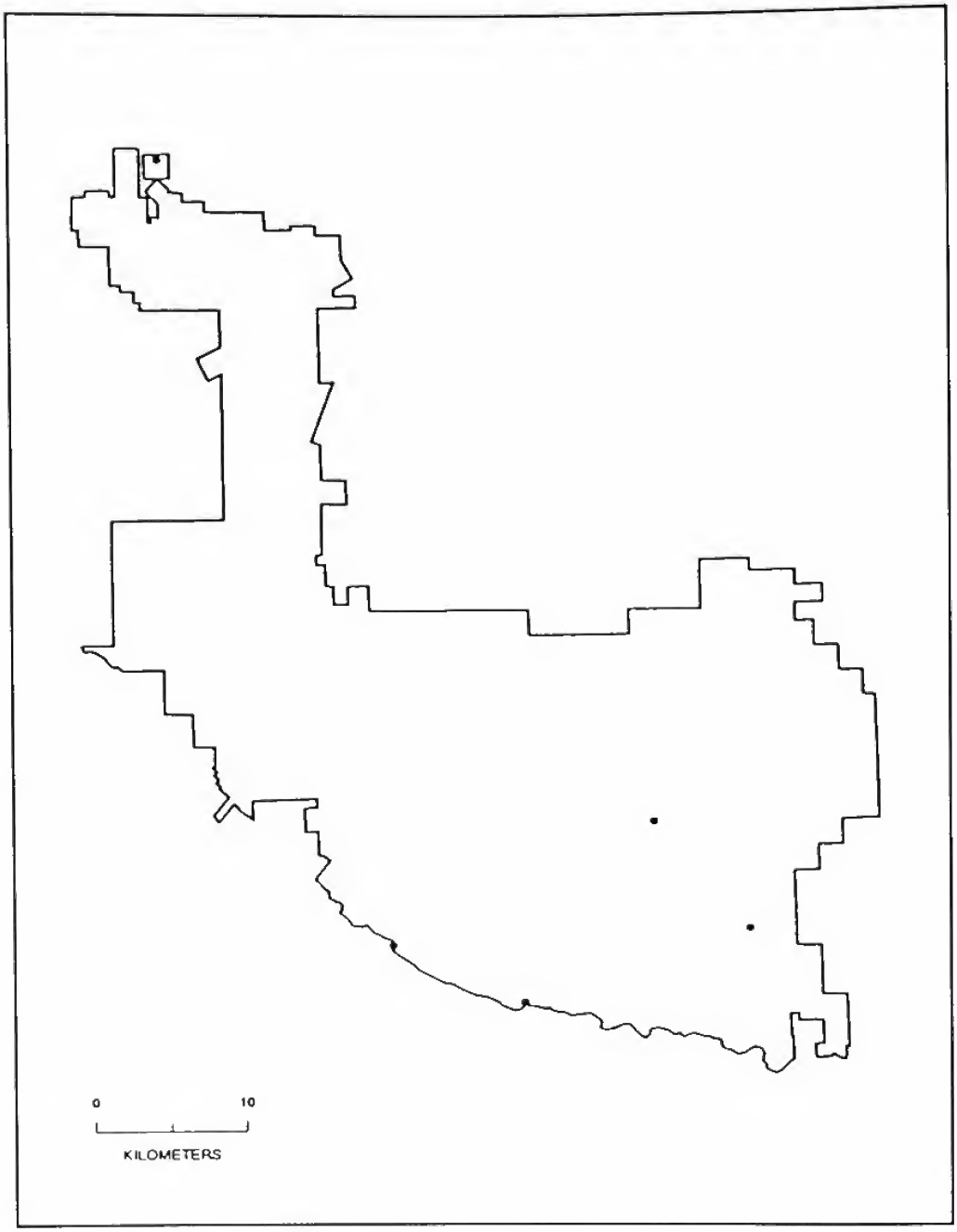

Figure 15. Localities of known specimens of *Myotis yumanensis* from Big Bend Ranch State Park, Texas.

etymology of the generic name. The specific epithet *yumanensis* refers to of (Old Fort) Yuma (Stangl et al., 1993).

Specimens Examined (6).— Presidio Co.: BBRSP, UTM coordinates: 13 576795E 3296125N, 1; BBRSP, UTM coordinates: 13 608608E 3253227N, 1; BBRSP, UTM coordinates: 13 614933E 3246380N, 2; BBRSP, Colorado Canyon, 1 (SRSU); BBRSP, 12 mi. W Lajitas, 1.

Pipistrellus hesperus (H. Allen, 1864)
Western Pipistrelle

Description.— *Pipistrellus hesperus* is the smallest bat that occurs at BBRSP. The dorsal pelage usually is smoky gray in color. A dark facial mask extends between the ears about the rostrum and eyes. The calcar of *P. hesperus* is keeled, and the tragus is short, curved, and blunt. The feet and ears are small. The dental formula for *P. hesperus* is: i 2/3, c 1/1, p 2/2, m 3/3, total 34.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult western pipistrelles from BBRSP are: total length, 76.4 (98, 69-90, 4.4); length of tail vertebrae, 32.5 (98, 26-39, 2.6); length of hind foot, 5.4 (99, 4-6, 0.5); length of ear from notch, 12.1 (98, 10-14, 0.7); weight, 3.8 (82, 2.0-6.5, 0.8); greatest length of skull, 12.46 (20, 11.88-13.06, 0.29). Females tend to be larger than males (Schmidly, 1991).

In BBRSP, *P. hesperus* might be mistaken for *Myotis californicus* and *M. ciliolabrum*. See the accounts of those two species for differentiation. *P. hesperus* conceivably could be confused with its congener, *P. subflavus*. However, the two can be distinguished easily based on coloration of pelage and tragus morphology. *P. hesperus* is smoky gray with a short, curved, blunt tragus, whereas *P. subflavus* has yellow-orange tricolored pelage, and a long, straight, pointed tragus. In addition, the calcar of *P. hesperus* is keeled, whereas that of *P. subflavus* lacks a keel.

Distribution.— *P. hesperus* ranges from central Mexico, northward throughout the southwestern United States, up to the Pacific Northwest (Hall, 1981). It occurs throughout BBRSP (Fig. 16), where it is the most widespread species of bat.

Natural History.— At BBRSP, *P. hesperus* had a relative abundance index of 0.534, and accounted for 34.4 percent of all bats netted. Based on these figures, the western pipistrelle is the most abundant bat at BBRSP.

Aside from being the most widespread and abundant bat at BBRSP, *P. hesperus* may also be the most ubiquitous in terms of habitat utilization. This bat was taken in most water-associated situations, whether in deep canyons, shallow canyons, or level conditions. It was found in both densely vegetated areas, as well as open areas with sparse or no vegetation. This bat also was taken frequently in desert scrub habitats that lacked any source of water. In addition, it often was observed flying about human dwellings. This species tends to roost alone or in small groups in rock crevices, under rocks, in burrows, and in man-made structures (Schmidly, 1991).

At BBRSP, *P. hesperus* was present and active throughout the year, having been taken during every month except January. Schmidly (1991) reports this bat to be sporadically active during winter, at which time it may become aroused during warm spells. This appears to be situation at BBRSP, as it was encountered much less frequently during the cooler months.

Prior to parturition, females form small maternity colonies of up to 12 individuals (Schmidly, 1991). I examined 17 gravid females taken from 29 April to 9 June, 12 of which were pregnant with twins, and five that contained a single embryo (mean, 1.7). Pregnant females (with number of embryos and corresponding crown-rump lengths in parentheses) were examined on the following dates: 29 April (2 embryos, crown-rump length, 5), 30 April (1 embryo, crown-rump length, 4), 3 May (2 embryos, crown-rump length, 8), 13 May (2 embryos, crown-rump length, 10), 14 May (1 embryo, crown-rump length, 9; 2 embryos, crown-rump length, 10), 15 May (1 embryo, crown-rump length, 14), 25 May (2 embryos, crown-rump length, 10), 28 May (2 embryos, crown-rump length, 11; 2 embryos, crown-rump length, 12), 29 May (2 embryos, crown-rump length, 9; 2 embryos, crown-rump length, 17; 2 embryos, crown-rump length, 18), and 9 June (1 embryo, crown-rump length, 16; 2 embryos, crown-rump length, 15; 2 embryos, crown-rump length, 16). Lactating females were noted from 21 June to 2 August. Volant juveniles were observed from 8 July through 22 August. Schmidly (1991) reports *P. hesperus* to give birth from June to July, and most of the data from this study concur. However, given a gestation period of about 40

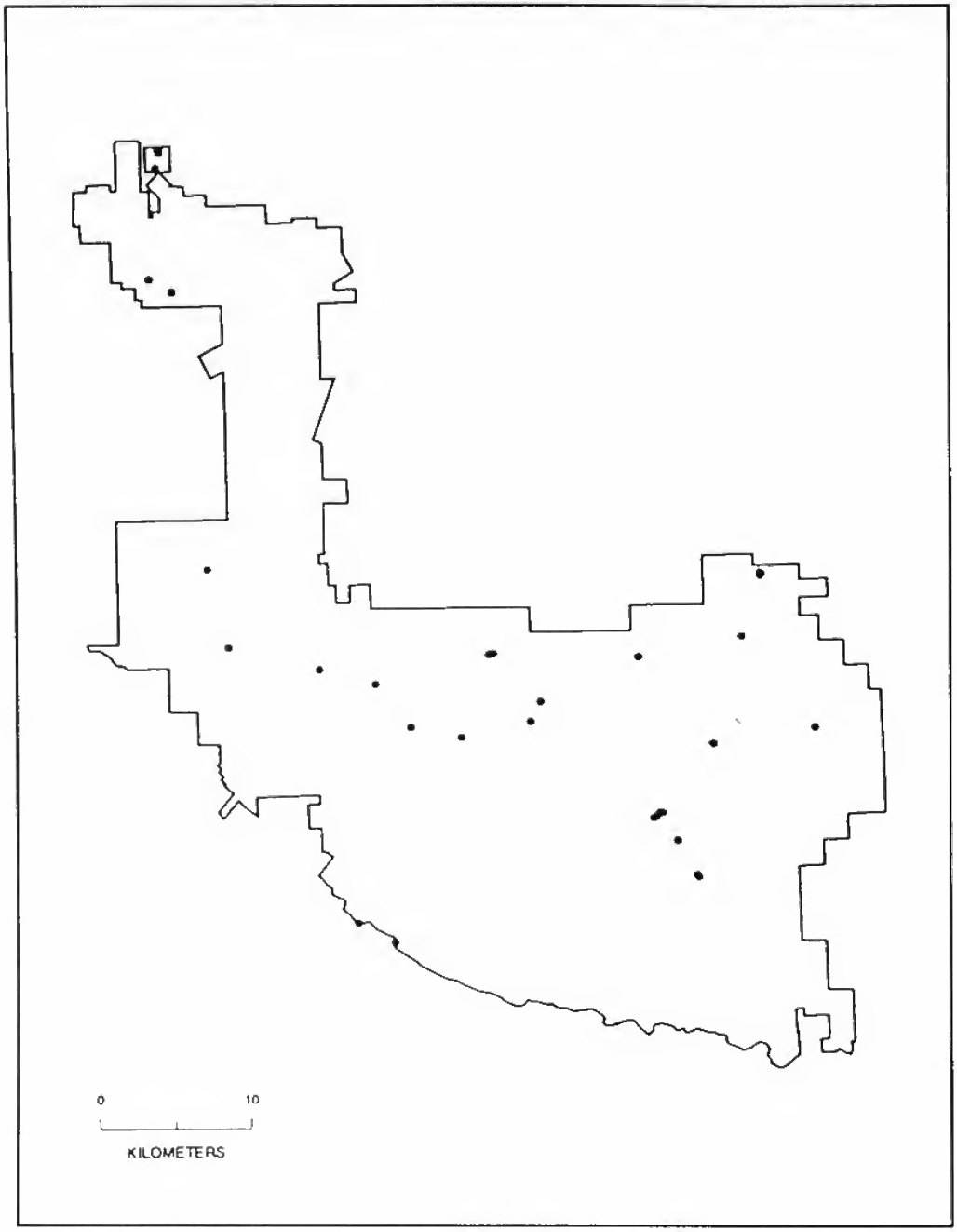

Figure 16. Localities of known specimens of *Pipistrellus hesperus* from Big Bend Ranch State Park, Texas.

days (Schmidly, 1991), it is conceivable that the females carrying 4 and 5 mm embryos in late April may have given birth in late May. Thus, parturition in BBRSP may occur from late May to July.

P. hesperus is known to exhibit two peaks in foraging activity, the first in the early evening and the second around dawn (Fitzgerald et al., 1994). At BBRSP, this bat was observed foraging very early in the evening, often as early as one hour before sunset. In the morning, it was observed foraging as late as 0930 h. This species feeds on a wide variety of small insects, including lepidopterans, coleopterans, trichopterans, plecopterans, homopterans, dipterans, and hymenopterans (Schmidly, 1991).

Other species of bats found at the same localities as *P. hesperus* at BBRSP included *Mormoops megalophylla*, *Myotis californicus*, *M. ciliolabrum*, *M. velifer*, *M. yumanensis*, *Eptesicus fuscus*, *Lasiurus cinereus*, *Plecotus townsendii*, *Antrozous pallidus*, *Tadarida brasiliensis*, and *Nyctinomops macrotis*. In addition, *Pipistrellus subflavus*, was taken in the near vicinity of *P. hesperus*, and the two should be considered to occur sympatrically in BBRSP.

Undetermined species of mites and ticks were observed on *P. hesperus* from BBRSP. Also, one individual was infected with an unidentified nematode. *P. hesperus* has been known to harbor the rabies virus (Constantine, 1988), but 60 individuals from BBRSP were examined for the virus; all proved negative (Yancey et al., 1997).

Comments.— The subspecies of *P. hesperus* at BBRSP is *P. h. maximus* Hatfield, 1936. The generic name *Pipistrellus* is derived from the Italian "pipistrello," which translates to bat. The specific epithet *hesperus* is from the Greek "hesperos," meaning of evening (Stangl et al., 1993).

Specimens Examined (123).— Presidio Co.: BBRSP, UTM coordinates: 13 576060E 3288074N, 2; BBRSP, UTM coordinates: 13 576609E 3295115N, 3; BBRSP, UTM coordinates: 13 576783E 3296292N, 5; BBRSP, UTM coordinates: 13 576823E 3296177N, 3; BBRSP, UTM coordinates: 13 576839E 3296085N, 1; BBRSP, UTM coordinates: 13 576842E 3296279N, 1; BBRSP, UTM coordinates: 13 577553E 3287272N, 4; BBRSP, UTM coordinates: 13 577563E 3287242N, 1; BBRSP, UTM coordinates: 13 579592E 3269404N, 1; BBRSP, UTM coordinates: 13 580916E 3264339N, 3; BBRSP, UTM coordinates: 13 586937E 3262923N, 24; BBRSP, UTM coordinates: 13 586938E 3262910N, 5; BBRSP, UTM coordinates: 13 589354E 3246455N, 1; BBRSP, UTM coordinates: 13 590668E 3261956N, 1; BBRSP, UTM coordinates: 13 592955E 3259156N, 3; BBRSP, UTM coordinates: 13 596232E 3258492N, 1; BBRSP, UTM coordinates: 13 598044E 3263850N, 3; BBRSP, UTM coordinates: 13 598124E 3263864N, 1; BBRSP, UTM coordinates: 13 598236E 3263889N, 1; BBRSP, UTM coordinates: 13 598326E 3263912N, 1; BBRSP, UTM coordinates: 13 600689E 3259514N, 2; BBRSP, UTM coordinates: 13 601325E 3260789N, 15; BBRSP, UTM coordinates: 13 607610E 3263630N, 1; BBRSP, UTM coordinates: 13 608477E 3253180N, 2; BBRSP, UTM coordinates: 13 608597E 3253243N, 2; BBRSP, UTM coordinates: 13 608608E 3253227N, 3; BBRSP, UTM coordinates: 13 608870E 3253520N, 1; BBRSP, UTM coordinates: 13 608955E 3253483N, 1; BBRSP, UTM coordinates: 13 611283E 3249529N, 1; BBRSP, UTM coordinates: 13 611393E 3249399N, 3; BBRSP, UTM coordinates: 13 614303E 3264882N, 1; BBRSP, UTM coordinates: 13 615525E 3268958N, 3; BBRSP, UTM coordinates: 13 615559E 3268762N, 1; BBRSP, UTM coordinates: 13 615565E 3268878N, 6; BBRSP, UTM coordinates: 13 615599E 3268863N, 9; BBRSP, UTM coordinates: 13 615650E 3268869N, 2; BBRSP, Colorado Canyon, 1 (SRSU); BBRSP, Smith Ranch, Fresno Canyon, 2 (SRSU); BBRSP, Burnt Camp, the Solitario, 1 (SRSU). Brewster Co.: BBRSP, Tres Papalotes, the Solitario, 1.

Pipistrellus subflavus (F. Cuvier, 1832)
Eastern Pipistrelle

Description.— *Pipistrellus subflavus* is a small bat with a pale yellow-orange dorsal pelage. The most distinguishing feature of this bat is the tricolored appearance of the fur. Each hair is dark at the base, paler in the middle, and dark at the tips. The feet and ears of this bat are relatively small in size. The calcar lacks a keel, and the tragus is straight and pointed. The dactylopatagium minus is distinctly paler than the rest of the wing membrane. The dental formula for *P. subflavus* is: i 2/3, c 1/1, p 2/2, m 3/3, total 34.

External and cranial measurements of a single adult male from BBRSP are: total length, 86; length of tail vertebrae, 38; length of hind foot, 8; length of ear from notch, 12; weight, 5.0; greatest length of skull, 12.67. Females typically are larger than males (Fujita and Kunz, 1984).

Other species of bats that occur at BBRSP that *P. subflavus* might be mistaken for include *Myotis californicus*, *M. ciliolabrum*, and *P. hesperus*. See the accounts of these species for distinguishing characters.

Distribution.— *P. subflavus* ranges from southeastern Mexico, northward through the eastern half of the United States, and into southeastern Canada (Fujita and Kunz, 1984). In BBRSP, the eastern pipistrelle was taken from a single locality in the Cienega area (Fig. 17). This locality is the only site in Trans-Pecos Texas from which *P. subflavus* has been recorded, and represents one of the western-most localities for the species.

Natural History.— A single specimen of *P. subflavus* was taken during this study, which resulted in a relative abundance index of 0.003. This species accounted for only 0.2 percent of all bats netted, and therefore should be considered very rare in BBRSP.

Because the specimen of *P. subflavus* taken during this study is the first from the Trans-Pecos, virtually nothing is known about the life history of this species in the area. This individual was taken along Cienega Creek among dense vegetation primarily composed of large willow and cottonwood trees. In Coahuila, Mexico, this bat was found to be restricted to this type of riparian habitat. There is speculation that *P. subflavus* reached Coahuila from the east by following the water-associated habitat along the Rio Grande, rather than traversing the inhospitable habitat of central Texas. It is suggested that this bat is linked to large trees found in riparian habitats, relying on them for roosting structures. In addition to trees, the eastern pipistrelle also may roost in caves, mines, rock crevices, and buildings (Schmidly, 1991).

The eastern pipistrelle acquired at BBRSP was taken in July. Elsewhere in Texas, it is known to hibernate within its summer range (Schmidly, 1991). Therefore, this bat should be considered a potential year round resident of BBRSP.

Female eastern pipistrelles form small nursery colonies, frequently at sites that are unsuitable for most other species of bats (Schmidly, 1991). No pregnant or lactating females were observed at BBRSP. Females are reported to give birth, usually to twins, in late May to early July. Young bats typically obtain the ability to fly by the age of one month (Schmidly, 1991).

P. subflavus often forages for insects over water at treetop level (Schmidly, 1991). This bat has a varied diet, and is known to feed on coleopterans, homopterans, dipterans, hymenopterans, and lepidopterans (Sherman, 1939; Ross, 1967; Whitaker, 1972).

Plecotus townsendii was the only other species of bat taken at the same locality as *P. subflavus* at BBRSP. However, several other species were taken in the same general area and habitat, and therefore should be considered to occur sympatrically with *P. subflavus*. These species were *Mormoops megalophylla*, *Myotis velifer*, *M. yumanensis*, *Pipistrellus hesperus*, *Eptesicus fuscus*, *Lasiurus cinereus*, and *Tadarida brasiliensis*.

No parasites were noted in association with the *P. subflavus* specimen from BBRSP. Ectoparasites reported previously from *P. subflavus* include numerous species of mites (Fujita and Kunz, 1984). Endoparasites known to infect *P. subflavus* include protozoans (Wheat, 1975) and trematodes (Macy, 1940; Jones, 1957). *P. subflavus* has been documented to harbor the rabies virus (Constantine, 1988; Schmidly, 1991), albeit at low levels (Fujita and Kunz, 1984). The single individual from BBRSP tested negative for this virus (Yancey et al., 1997).

Comments.— The single specimen of *P. subflavus* taken from BBRSP tentatively has been assigned to the subspecies *P. s. clarus* Baker, 1954 (Yancey et al., 1995). However, the color of this specimen does not appear to be as pale as that described for other specimens of *P. s. clarus*. Additional specimens of this bat are necessary in order to resolve the systematics of this taxon in BBRSP. See the account on *Pipistrellus hesperus* for the etymology of the generic name. The specific epithet *subflavus* is from the Latin "sub" and "flavus," meaning under and yellow, respectively (Stangl et al., 1993).

Specimens Examined (1).— Presidio Co.: BBRSP, UTM coordinates: 13 576658E 3296469N, 1.

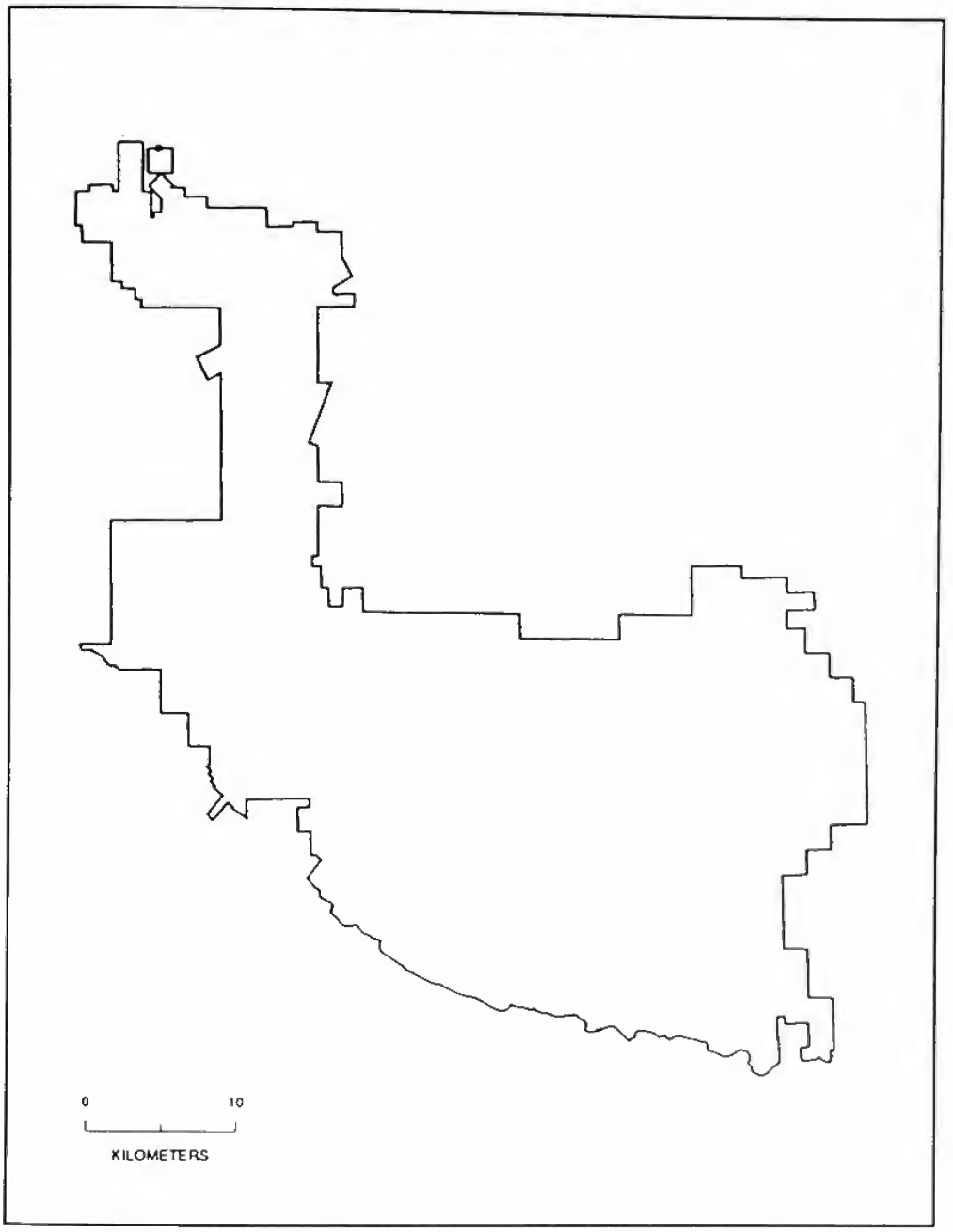

Figure 17. Localities of known specimens of *Pipistrellus subflavus* from Big Bend Ranch State Park, Texas.

Eptesicus fuscus
(Palisot de Beauvois, 1796)
Big Brown Bat

Description.— Eptesicus fuscus is a large bat with a pale to chocolate brown dorsal pelage. The tragus is short, broad, and curved, and its calcar is keeled. The dental formula for *E. fuscus* is: i 2/3, c 1/1, p 1/2, m 3/3, total 32.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult big brown bats from BBRSP are: total length, 116.4 (44, 104-126, 4.8); length of tail vertebrae, 51.2 (44, 43-59, 4.2); length of hind foot, 10.1

(44, 9-11, 0.5); length of ear from notch, 17.9 (44, 16-19, 0.7); weight, 15.2 (41, 9.5-19, 2.2); greatest length of skull, 19.36 (20, 18.29-20.02, 0.52). Females tend to be slightly larger than males (Schmidly, 1991).

The color, size, and tragus morphology of *E. fuscus* make it difficult to confuse this bat with any other species of bat that occurs at BBRSP.

Distribution.— *E. fuscus* ranges from northern South America, northward through Central America, on into and across all of the United States and southern Canada. It also is present on several of the Caribbean Islands (Kurta and Baker, 1990). In BBRSP, *E. fuscus* was recorded from the Cienega, Las Quevas, Sauceda, Arroyo Segundo, and Los Alamos areas (Fig. 18).

Natural History.— With a relative abundance index of 0.163, *E. fuscus* was the fourth most frequently netted bat. It comprised 9.9 percent of all bats netted. These results indicate that the big brown bat is relatively common in the park.

Most specimens of *E. fuscus* acquired at BBRSP were taken near small springs or streams associated with cottonwood and willow trees. One individual was taken near a human dwelling. However, this bat seems to be a habitat generalist (Furlonger et al., 1987), and therefore, may occur in any of the habitats present at BBRSP. *E. fuscus* is known to roost in hollow trees, but also may utilize rock crevices, tunnels, and man-made structures (Kurta and Baker, 1990). In Big Bend National Park, Easterla (1973) found evidence that the sexes segregate by elevation during the summer. He proposed that females set up nursery colonies at lower elevations, while the males spend the summer at cooler high elevations. Although females outnumbered males almost two to one (29 to 16) in the lowlands of BBRSP during the summer, segregation of the sexes does not appear to be the situation, as males and females were taken together on numerous occasions.

During this study, *E. fuscus* was taken from 11 April to 4 September. No winter records of this species exist from Trans-Pecos Texas, but it is believed to hibernate in the area over winter (Easterla, 1973). In BBRSP, it probably is a year round resident, probably being active only during the warmer months.

Little is known on the reproductive biology of *E. fuscus* in the Trans-Pecos. In Texas in general, parturition occurs from late May to June. *E. fuscus* from the eastern part of the state typically gives birth to twins, whereas only a single young is produced in West Texas. Based on this information, it is assumed that *E. fuscus* in the Trans-Pecos gives birth to a single young in May or June (Schmidly, 1991). I examined a single gravid female taken on 5 May that was carrying one embryo with a crown-rump length of 9. Lactating females were noted on 23 June, and 5, 10, 15, and 16 July. Volant juveniles were observed among the population on 18, 24, 25, and 31 July, and 4 September.

E. fuscus is known to forage throughout the night, but the majority of feeding activity occurs within two hours following sunset (Kunz, 1973*b*). At BBRSP, this bat was one of the first bats seen foraging in the evening. It frequently was observed flying about shortly after sunset. *E. fuscus* primarily feeds on small coleopterans (Freeman, 1981; Mumford and Whitaker, 1982). In addition, it is known to prey on isopterans, hemipterans, homopterans, and hymenopterans (Ross, 1967).

Other species of bats taken in association with *E. fuscus* at BBRSP were *Mormoops megalophylla*, *Myotis californicus*, *M. thysanodes*, *M. velifer*, *M. yumanensis*, *Pipistrellus hesperus*, *Lasiurus cinereus*, *Plecotus townsendii*, *Antrozous pallidus*, *Tadarida brasiliensis*, and *Nyctinomops macrotis*.

Mites and ticks were found on *E. fuscus* from BBRSP. Several insects also are known to infest *E. fuscus* (Kurta and Baker, 1990). Endoparasites of *E. fuscus* include protozoans (Bower and Woo, 1981), trematodes, cestodes, and nematodes (Kurta and Baker, 1990). *E. fuscus* has been implicated as a reservoir for rabies on several occasions (Kurta and Baker, 1990), but of 12 specimens from BBRSP that were tested for the virus, none was positive (Yancey et al., 1997). *E. fuscus* also has been implicated as a host for St. Louis encephalitis virus and the fungus *Histoplasma capsulatum* (Kurta and Baker, 1990), the etiologic agent of histoplasmosis (Rippon, 1982).

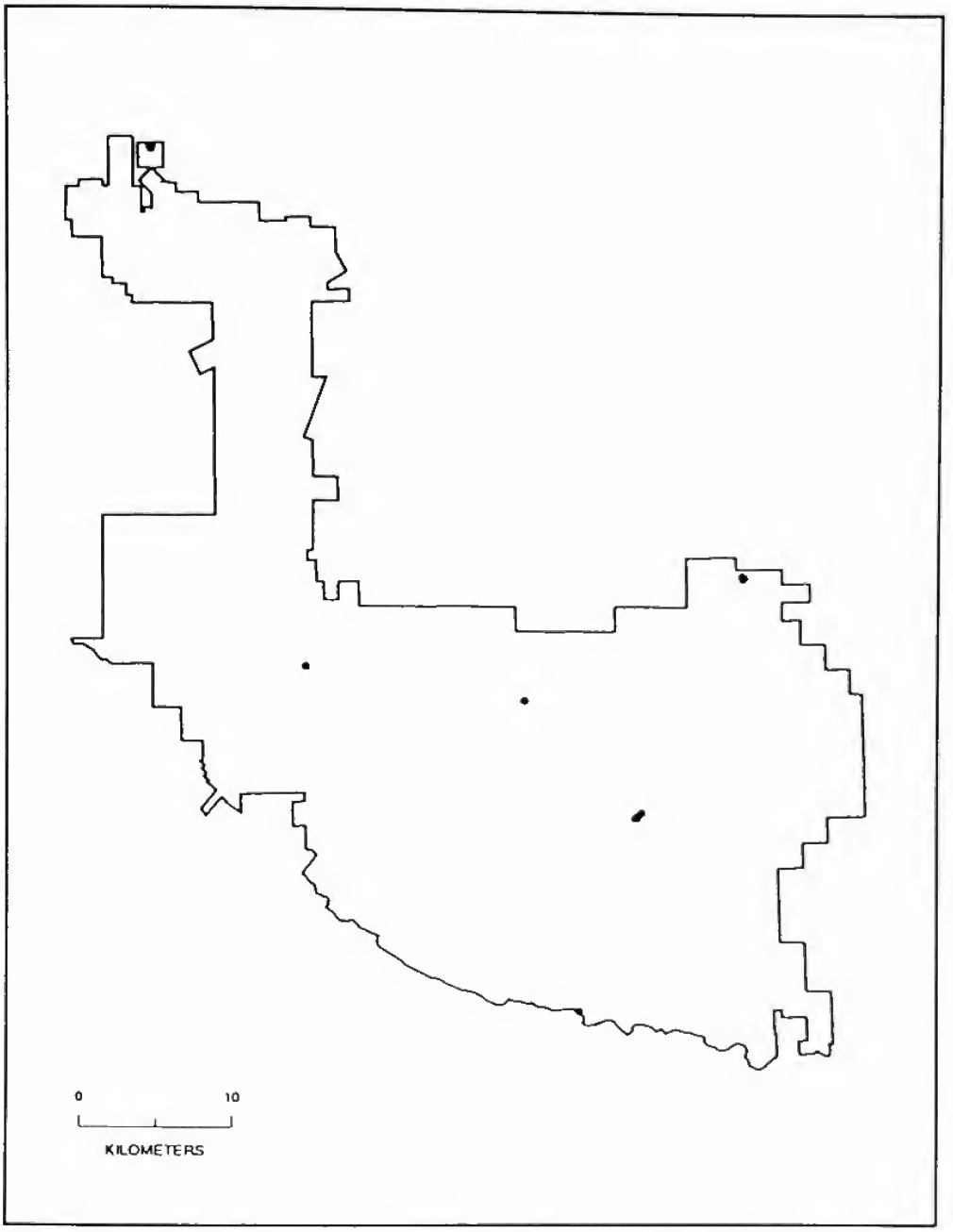

Figure 18. Localities of known specimens of *Eptesicus fuscus* from Big Bend Ranch State Park, Texas.

Comments.— The subspecies of *E. fuscus* at BBRSP is *E. f. pallidus* Young, 1908. The generic name *Eptesicus* is derived from the Greek "petesthai" and "oikos," which translate to fly and house, respectively. The specific epithet *fuscus* is from the Latin "fuscus," meaning dusky (Stangl et al., 1993).

Specimens Examined (50).— Presidio Co.: BBRSP, UTM coordinates: 13 576699E 3296276N, 3; BBRSP, UTM coordinates: 13 576783E 3296292N, 5; BBRSP, UTM coordinates: 13 576795E 3296125N, 2; BBRSP, UTM coordinates: 13 576842E 3296279N, 1; BBRSP, UTM coordinates: 13 586937E 3262923N, 1; BBRSP, UTM coordinates: 13 586938E 3262910N, 1; BBRSP, UTM coordinates: 13 601325E 3260789N,

4; BBRSP, UTM coordinates: 13 604886E 3240689N,
1; BBRSP, UTM coordinates: 13 608477E 3253180N,
1; BBRSP, UTM coordinates: 13 608597E 3253243N,
1; BBRSP, UTM coordinates: 13 608608E 3253227N,
3; BBRSP, UTM coordinates: 13 608870E 3253520N,
4; BBRSP, UTM coordinates: 13 615525E 3268958N,
3; BBRSP, UTM coordinates: 13 615559E 3268762N,
1; BBRSP, UTM coordinates: 13 615565E 3268878N,
2; BBRSP, UTM coordinates: 13 615599E 3268863N,
16; BBRSP, UTM coordinates: 13 615650E 3268869N,
1.

Lasiurus cinereus
(Palisot de Beauvois, 1796)
Hoary Bat

Description.— *Lasiurus cinereus* is a large bat with heavy, dark brown dorsal pelage that is frosted with white. The face of this bat is yellowish. The feet are large, and the ears are relatively short and round. As with all members of the genus, the dorsal surface of the uropatagium is heavily furred. The dental formula for *L. cinereus* is: i 1/3, c 1/1, p 2/2, m 3/3, total 32.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult hoary bats from BBRSP are: total length, 133.5 (6, 120-143, 8.2); length of tail vertebrae, 59.1 (6, 51-66, 6.0); length of hind foot, 10.3 (6, 9-12, 1.0); length of ear from notch, 17.3 (6, 16-19, 1.2); weight, 21.3 (6, 16-29, 4.8); greatest length of skull, 16.72 (6, 14.85-17.51, 0.98). Significant sexual dimorphism has been reported in *L. cinereus*, with females averaging larger than males (Williams and Findley, 1979).

Because of its size and distinct coloration, it is difficult to confuse the hoary bat with any other species of bat at BBRSP.

Distribution.— *L. cinereus* is the most widespread bat in the New World. It ranges from southern South America, up through parts of western South America to northwestern South America. There is a hiatus in its distribution between northern South America and northern Central America. From northern Central America, it ranges on up through Mexico, northward throughout most of the United States and into much of Canada. In addition, it is known from several island localities, including the Hawaiian Islands (Shump and Shump, 1982). In BBRSP, *L. cinereus* is known from the Cienega area, Las Cuevas, and Chorro Canyon (Fig. 19).

Natural History.— At BBRSP, *L. cinereus* had a relative abundance index of 0.018. This species represented 1.1 percent of all bats netted during this study. These data indicate that the hoary bat is rather uncommon in the park. This bat was considered uncommon in Big Bend National Park as well (Easterla, 1973).

Schmidly (1991) reported that in the Trans-Pecos, the hoary bat is restricted to montane woodlands. However, all specimens of *L. cinereus* taken at BBRSP were acquired from lowland riparian woodlands. Vegetation at all sites was dominated by dense stands of cottonwood and willow trees. *L. cinereus* is a tree-roosting bat (Shump and Shump, 1982), and undoubtedly roosts among the foliage of these trees.

L. cinereus was recorded at BBRSP during April, May, and September. This is a migratory species, and may occur in BBRSP only during the spring and fall while migrating through the area. Females are thought to begin migratory movements prior to males and the sexes are thought to segregate during the summer months. Females move to the northern, eastern, and central United States to give birth and raise their young. In contrast, males summer in the mountains of the west (Findley and Jones, 1964). This appears to be the situation at Big Bend National Park where only males are found in the Chisos Mountains during the summer, and only females or known from the park during the spring and fall (Easterla, 1973). Fall migration commences in August, and although not documented, sexual segregation during this activity was suggested by Findley and Jones (1964). At BBRSP during early September, an adult male hoary bat was taken along with numerous female hoary bats at the same general time and locality. This discounts the possibility of complete segregation of the sexes during fall migration. Because of the absence of summer records, and the lack of suitable montane habitat, such as that found in Big Bend National

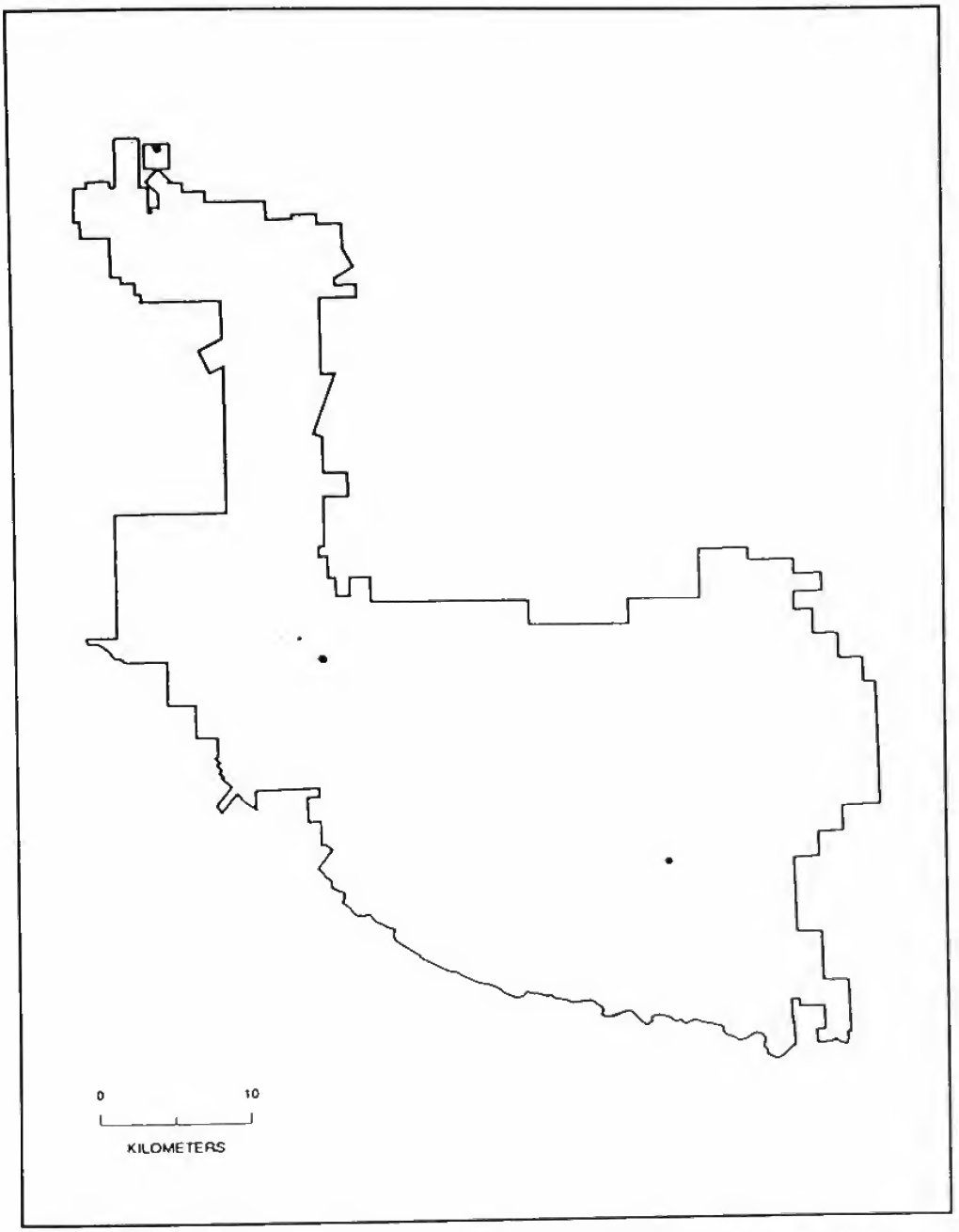

Figure 19. Localities of known specimens of *Lasiurus cinereus* from Big Bend Ranch State Park, Texas.

Park, *L. cinereus* probably occurs in BBRSP only as a spring-fall migrant.

Little is known about the reproductive habits of hoary bats in the Trans-Pecos. Females are thought to give birth from mid-May to early July (Schmidly, 1991). Litters typically consist of two young, but may range from one to four (Shump and Shump, 1982). A single female taken at BBRSP on 18 May was gravid with two embryos (crown-rump length, 14). Young usually obtain the ability to fly by 33 days of age.

L. cinereus typically begins to forage late in the evening (Shump and Shump, 1982). This bat seems to

favor lepidopterans (Ross, 1967; Black, 1972), but also may feed on coleopterans, dipterans, orthopterans, isopterans, odonatans, and hymenopterans (Shump and Shump, 1982).

Several species of bats were taken at the same localities as *L. cinereus*, but at different times of the year. *Tadarida brasiliensis* was the only bat taken at the same place and time as *L. cinereus*.

No parasites were noted in association with *L. cinereus* from BBRSP. Previously reported external parasites of *L. cinereus* include various species of mites. Protozoans and various helminths are known endoparasites of hoary bats. *L. cinereus* has been reported as having a high incidence of rabies (Shump and Shump, 1982). Schmidly (1991) reported that 25 percent of hoary bats tested by the Texas Department of Health from 1984 to 1987 were positive; this was the highest frequency observed among Texas bats. However, this figure was based on a sample of only 40 specimens. No hoary bats obtained from BBRSP during this study were tested for rabies.

Comments.— The subspecies of *L. cinereus* at BBRSP is *L. c. cinereus* (Palisot de Beauvois, 1796). The generic name *Lasiurus* is derived from the Greek "lasios" and "oura," which translate to shaggy and tail, respectively. The specific epithet *cinereus* is from the Latin "cinereus," meaning ashen (Stangl et al., 1993).

Specimens Examined (6).— Presidio Co.: BBRSP, UTM coordinates: 13 576783E 3296292N, 2; BBRSP, UTM coordinates: 13 576823E 3296177N, 2; BBRSP, UTM coordinates: 13 576844E 3296174N, 1; BBRSP, UTM coordinates: 13 609585E 3249854N, 1.

Plecotus townsendii Cooper, 1837
Townsend's Big-eared Bat

Description.— *Plecotus townsendii* is a medium-sized bat with a pale brown dorsal pelage. The ears of this bat are distinctively large. An obvious lump-like facial gland is present on both sides of the nose. The dental formula for *P. townsendii* is: i 2/3, c 1/1, p 2/3, m 3/3, total 36.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 97.3 (10, 90-105, 5.4); length of tail vertebrae, 47.0 (10, 43-50, 2.3); length of hind foot, 9.1 (10, 8-11, 1.2); length of ear from notch, 35.0 (10, 34-37, 0.8); weight, 8.2 (10, 6.7-9.0, 0.6); greatest length of skull, 16.05 (9, 15.56-16.39, 0.26). Females may average slightly larger in size than males (Kunz and Martin, 1982).

The only other bat known to occur in BBRSP that *P. townsendii* might be confused with is *Antrozous pallidus*. Both of these bats are pale in color, and both possess noticeably long ears. However, the two can be distinguished easily on the basis of color, length of ears, and presence or absence of conspicuous nose lumps. *P. townsendii* is pale brown, has ear measurements greater than 30, and possesses two distinct nose lumps. In contrast, *A. pallidus* is pale yellow to cream, has ear measurements usually less than 30, and lacks distinct nose lumps.

Distribution.— *P. townsendii* ranges from central Mexico, northward throughout the western United States, and into southern British Columbia (Kunz and Martin, 1982). In BBRSP, this bat is known from the Cienega, Sauceda, Los Alamos, Arroyo Segundo, and Fresno Canyon areas (Fig. 20).

Natural History.— At BBRSP, *P. townsendii* had a relative abundance index of 0.027. This bat accounted for 2.0 percent of all bats netted. These figures suggest that *P. townsendii* is rather uncommon in BBRSP. This bat was found to be somewhat more abundant in nearby Big Bend National Park (Easterla, 1973).

In BBRSP, *P. townsendii* was netted over small streams and springs, all of which were associated with riparian woodland habitat. In addition, specimens were acquired from inside Whitroy Mine. This mine is situ-

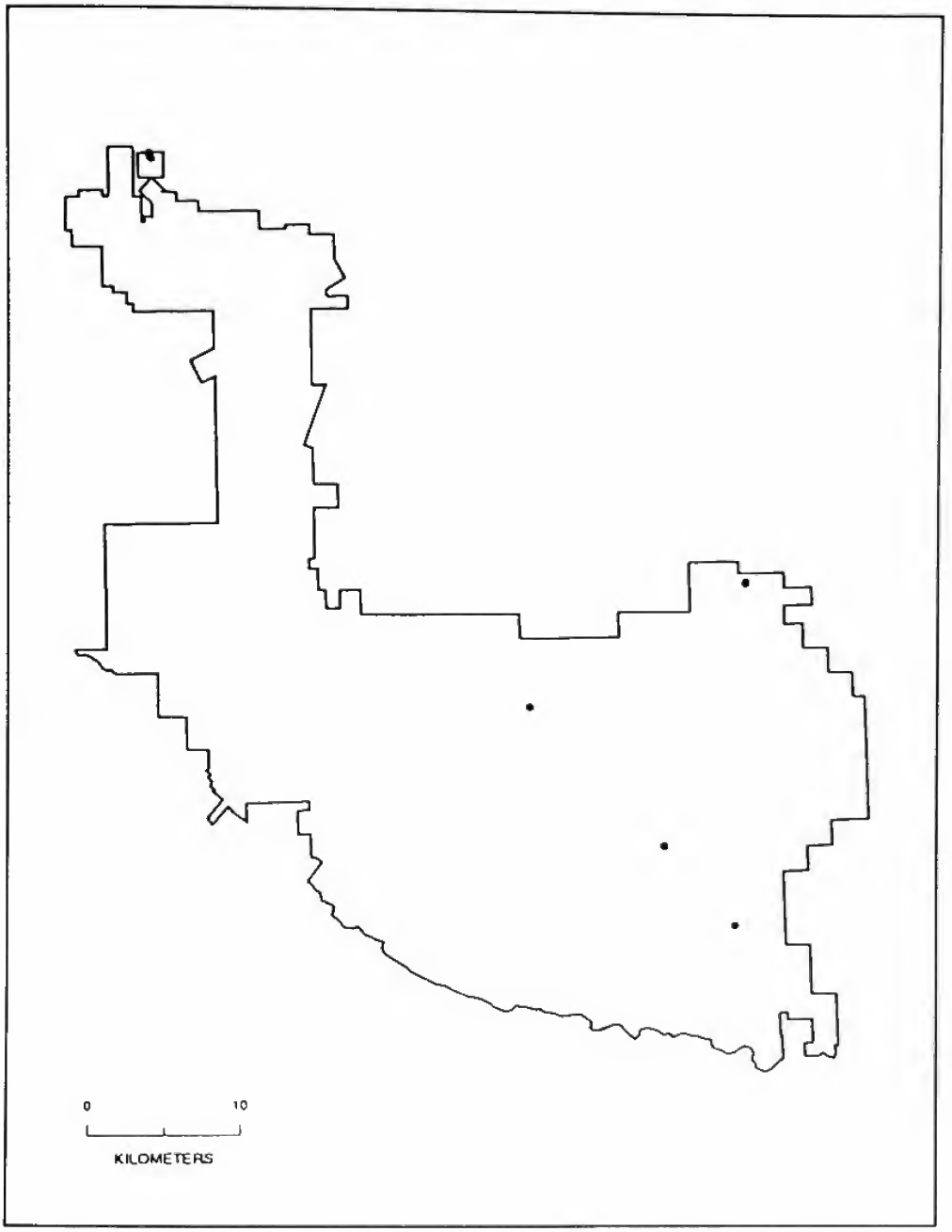

Figure 20. Localities of known specimens of *Plecotus townsendii* from Big Bend Ranch State Park, Texas.

ated among desert scrub dominated by creosote-bush. The distribution of this bat apparently is not a function of floral associations (Schmidly, 1991). Rather, its distribution appears to be correlated with the abundance of preferred roost sites, especially caves and abandoned mines (Davis and Schmidly, 1994). Therefore, *P. townsendii* potentially could occur almost anywhere in BBRSP where these structures exist.

Townsend's big-eared bat was recorded at BBRSP from 20 March to 3 September. It is known to hiber-

nate in tight clusters in local caves rather than migrate (Schmidly, 1991), and should be considered a year round resident of the park.

During summer, females form small to medium-sized maternity colonies consisting of 12 to 200 individuals. Birth is given to a single young in late May or early June (Schmidly, 1991). Lactating females were observed at BBRSP on 5, 6, 8, and 9 July. Juveniles obtain the capability of flight by week three, and are weaned by six weeks of age (Kunz and Martin, 1982).

P. townsendii is considered a late-evening forager (Kunz and Martin, 1982), although during this study it was taken infrequently during the early evening. This bat is considered an aerial insectivore, but is known occasionally to glean prey from leaves of plants (Kunz and Marti, 1982). *P. townsendii* primarily feeds on small lepidopterans, but also is known to consume neuropterans, coleopterans, dipterans, and hymenopterans (Hamilton, 1943; Ross, 1967; Whitaker et al., 1977).

Bats netted in sympatry with *P. townsendii* at BBRSP included *Mormoops megalophylla*, *Myotis californicus*, *M. thysanodes*, *M. velifer*, *M. yumanensis*, *Pipistrellus hesperus*, *Pipistrellus subflavus*, *Eptesicus fuscus*, and *Antrozous pallidus*.

Ectoparasites noted infesting *P. townsendii* at BBRSP included ticks and a wingless bat fly (Nycteribiidae). *P. townsendii* from Big Bend National Park is known to be infested with the nycteribiid *Basilia corynorhini* (Whitaker and Easterla, 1975), and it is likely that this was the species of wingless bat fly infesting *P. townsendii* at BBRSP. Other external parasites reported from *P. townsendii* include various species of mites and ticks, and a winged bat fly (Streblidae). Internal parasites documented to infect *P. townsendii* include protozoans, cestodes, and nematodes (Kunz and Martin, 1982). Townsend's big-eared bat is known to be afflicted by rabies (Constantine, 1967; 1988). Four individuals from BBRSP were tested for the virus, but all proved negative (Yancey et al., 1997).

Comments.— The subspecies of *P. townsendii* at BBRSP is *P. t. pallescens* (Miller, 1897). The generic name *Plecotus* is derived from the Greek "plekos" and "tous," which translate to twist or braid, and ear, respectively. The specific epithet *townsendii* refers to Townsend's (Stangl et al., 1993). Many workers (e.g., Menue, 1987; Tumlison and Douglas, 1992) consider New World members of the genus *Plecotus* as members of the genus *Corynorhinus*. If this view is followed, Townsend's big-eared bat would be recognized as *Corynorhinus townsendii*.

Specimens Examined (11).— Presidio Co.: BBRSP, UTM coordinates: 13 576658E 3296469N, 3; BBRSP, UTM coordinates: 13 576699E 3296276N, 1; BBRSP, UTM coordinates: 13 576795E 3296125N, 2; BBRSP, UTM coordinates: 13 601325E 3260789N, 1; BBRSP, UTM coordinates: 13 614672E 3246532N, 2; BBRSP, UTM coordinates: 13 615559E 3268762N, 1; BBRSP, Smith Ranch, Fresno Canyon, 1 (SRSU).

Antrozous pallidus (Le Conte, 1856)
Pallid Bat

Description.— *Antrozous pallidus* is a medium-sized bat with pale yellowish dorsal pelage, often with pale brown or gray blotches. The ears of this bat are moderately large. The dental formula for *A. pallidus* is: i 1/2, c 1/1, p 1/2, m 3/3, total 28.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 107.2 (35, 92-115, 4.6); length of tail vertebrae, 45.8 (35, 31-54, 4.5); length of hind foot, 10.7 (36, 9-13, 0.9); length of ear from notch, 28.9 (35, 24-31, 1.4); weight, 13.5 (33, 10.5-19, 1.9); greatest length of skull, 19.29 (20, 18.57-19.96, 0.42). Males often are slightly smaller than females (Schmidly, 1991).

The only other bat known to occur in BBRSP that *A. pallidus* might be confused with is *Plecotus townsendii*. See the account of the latter for differentiation.

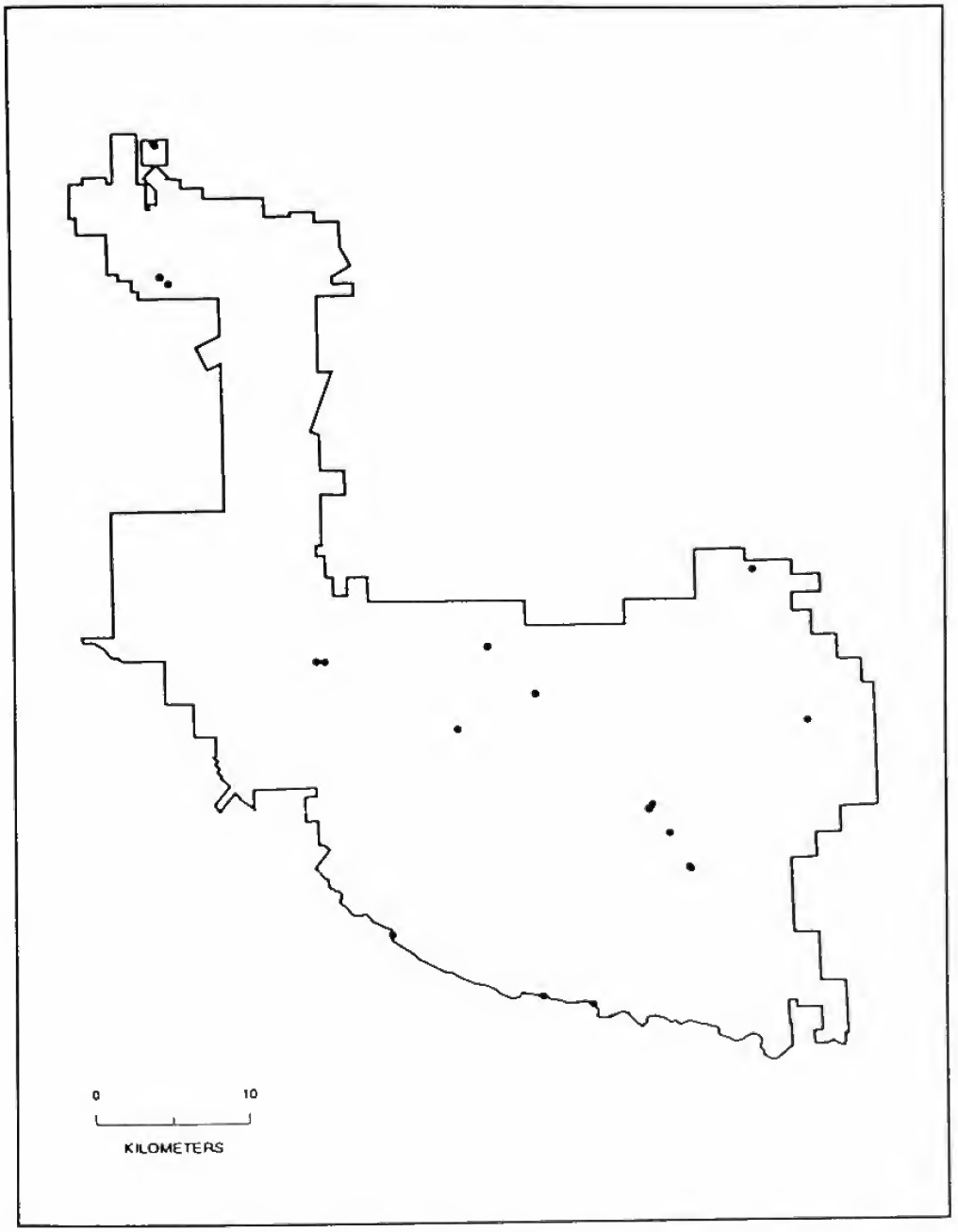

Figure 21. Localities of known specimens of *Antrozous pallidus* from Big Bend Ranch State Park, Texas.

Distribution.— *A. pallidus* ranges from central Mexico and Baja California, northward throughout the southwestern United States, up through the Pacific Northwest, and into southern British Columbia (Hermanson and O'Shea, 1983). At BBRSP, this bat was fairly widespread, being found at several localities scattered throughout the park (Fig. 21).

Natural History.— With a relative abundance index of 0.131, *A. pallidus* was the fifth most frequently netted bat at BBRSP. It accounted for 7.8 percent of all bats netted. Although these results suggest that the pallid bat is not uncommon in BBRSP, it is not as abundant as in Big Bend National Park, where it was reported as the most common bat in the park (Easterla, 1973).

A. pallidus frequently was taken along water courses in BBRSP. It was acquired from cottonwood-willow associations near small streams and pools, as well as from tamarisk-mesquite associations along the Rio Grande. In addition it was taken over water tanks in desert scrub dominated by creosote-bush. Pallid bats tend to roost in small colonies (12 to 100 individuals) within rock crevices, caves, tunnels, in buildings (Schmidly, 1991), and possibly hollow trees (Orr, 1954).

A. pallidus was recorded at BBRSP from 19 March to 16 September. There are no records of this bat from Texas during any other time of year. This bat is not known to undergo long migrations, and therefore, is thought to hibernate within its summer range (Schmidly, 1991). Therefore, *A. pallidus* should be considered a probable year round resident of BBRSP.

Little information on the reproductive biology of the pallid bat in the Trans-Pecos has been documented. Distribution-wide, this bat is reported to give birth to one to four young (Manning et al., 1987) in May or June (Hermanson and O'Shea, 1983). However, a single pregnant female taken on 28 May near Boquillas, Coahuilla, Mexico (Bailey, 1905) led Easterla (1973) to speculate that parturition in the Big Bend area occurs earlier, probably in May only. I examined 5 gravid females taken between 27 May and 9 June, 2 of which were pregnant with twins, and three that carried a single embryo (mean, 1.4). Pregnant females (with number of embryos and corresponding crown-rump lengths in parentheses) were examined on the following dates: 27 May (1 embryo, crown-rump length, 19; 1 embryo, crown-rump length, 21), 7 June (2 embryos, crown-rump length, 25), and 9 June (1 embryo, crown-rump length, 26; 2 embryos, crown-rump length, 28). Lactating females were noted from 4 July to 21 July. Volant juveniles were observed from 13 July through 29 July. These data indicate that the time of parturition in the Big Bend area is not restricted to May, but probably occurs from May to mid-June.

The foraging behavior of *A. pallidus* is somewhat unusual for a bat. This bat primarily is an insectivore that sometimes, like other insectivouous bats, pursues its prey in flight. However, it more often gleans its prey from the ground or vegetation surfaces. Its diet is highly variable, but seems to mostly consist of large insects 20 to 70 mm in length. Major insect prey items include orthopterans, coleopterans, homopterans, and lepidopterans. In addition to insect prey, *A. pallidus* also is reported to forage upon additional taxa of flightless arthropods, most notably arachnids such as scorpions and solpugids (Hermanson and O'Shea, 1983). On occasion, the muzzles of individuals taken at BBRSP were covered with plant pollen. These bats probably were not feeding on the pollen or nectar of the plant, but rather encountered the pollen while foraging on arthropods that feed on flower parts (Herrera M. et al., 1993).

Other species of bats taken in association with *A. pallidus* at BBRSP included *Mormoops megalophylla*, *Myotis californicus*, *M. thysanodes*, *M. velifer*, *M. yumanensis*, *Pipistrellus hesperus*, *Eptesicus fuscus*, *Plecotus townsendii*, *Tadarida brasiliensis*, and *Nyctinomops macrotis*.

Ectoparasites taken from *A. pallidus* at BBRSP included unidentified species of mites and ticks. Also, several individuals were infested with wingless bat flies of the Family Nycteribiidae. In addition to these parasites, this bat is known to be infested with bedbugs and fleas. Internal parasites known to infect *A. pallidus* include protozoans (Hermanson and O'Shea, 1983). Pallid bats are known to be infected with the rabies virus (Hermanson and O'Shea, 1983, Constantine, 1988), but of 27 specimens from BBRSP that were tested for rabies, all were negative (Yancey et al ., 1997). Also of medical importance, pallid bats harbor bacteria of the Genus *Borrelia* (Hermanson and O'Shea, 1983), the genus of the etiologic agents of relapsing fever (Joklik et al., 1980) and Lyme disease (Tierno, 1990).

Comments.— The subspecies of *A. pallidus* at BBRSP is *A. p. pallidus* (Le Conte, 1856). The generic name *Antrozous* is derived from the Greek "antron" and "zoos," which translate to cave, and living, respectively. The specific epithet *pallidus* is from the Latin "pallidus" meaning pale (Stangl et al., 1993).

Specimens Examined (48).— Presidio Co.: BBRSP, UTM coordinates: 13 576699E 3296276N, 1; BBRSP, UTM coordinates: 13 576795E 3296125N, 2; BBRSP, UTM coordinates: 13 577000E 3287710N, 1; BBRSP, UTM coordinates: 13 577553E 3287272N, 1; BBRSP, UTM coordinates: 13 586937E 3262923N, 1; BBRSP, UTM coordinates: 13 587490E 3262902N, 1; BBRSP, UTM coordinates: 13 596232E 3258492N, 2; BBRSP, UTM coordinates: 13 598236E 3263889N, 3; BBRSP, UTM coordinates: 13 601325E 3260798N, 7; BBRSP, UTM coordinates: 13 601335E 3260787N, 1; BBRSP, UTM coordinates: 13 601632E 3241210N, 1; BBRSP, UTM coordinates: 13 604886E 3240689N, 5; BBRSP, UTM coordinates: 13 608608E 3253227N, 3; BBRSP, UTM coordinates: 13 608776E 3253333N, 1; BBRSP, UTM coordinates: 13 608870E 3253520N, 3; BBRSP, UTM coordinates: 13 611283E 3249529N, 1; BBRSP, UTM coordinates: 13 611393E 3249399N, 1; BBRSP, UTM coordinates: 13 615599E 3268863N, 7; BBRSP, Colorado Canyon, 2 (SRSU); BBRSP, Arroyo Segundo, 1 (SRSU); BBRSP, Smith Ranch, Fresno Canyon, 1 (SRSU). Brewster Co.: BBRSP, the Solitario, Tres Papalotes, 2 (SRSU).

Family Molossidae (Free-tailed Bats)

Tadarida brasiliensis (I. Geof. St.-Hilaire, 1824)
Brazilian Free-tailed Bat

Description.— *Tadarida brasiliensis* is a medium-sized bat with uniform dark brown to dark gray dorsal pelage. The posterior third of the tail of this bat, as in all molossids, extends beyond the trailing edge of the uropatagium. The ears of *T. brasiliensis* are relatively broad and are not joined. Vertical folds are present on the lateral sides of the lips. The dental formula for *T. brasiliensis* is: i 1/2 or i 1/3, c 1/1, p 2/2, m 3/3, total 30 or 32.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 93.7 (53, 87-103, 3.6); length of tail vertebrae, 35.2 (53, 26-44, 3.1); length of hind foot, 8.2 (53, 7-10, 0.7); length of ear from notch, 17.8 (53, 15-19, 1.0); weight, 10.7 (46, 6.5-13, 1.1); greatest length of skull, 16.64 (20, 15.99-17.28, 0.38). Males average slightly larger than females for most measurements (Wilkins, 1989).

Two other species of free-tailed bats are known from BBRSP. Both are similar in appearance, but can be distinguished easily from *T. brasiliensis* on the basis of size. Both *Nyctinomops macrotis* and *Eumops perotis* are considerably larger than *T. brasiliensis*. Furthermore, the base of the ears of *T. brasiliensis* are not fused at the midline of the head, whereas they are in the other free-tails at BBRSP. Potential confusion may exist if *Nyctinomops femorosaccus* is encountered in BBRSP. Currently, this species is unknown from the park, but has been recorded from nearby Big Bend National Park. It is similar in appearance and size, but, as in the other non-tadarid free-tailed bats at BBRSP, its ears are joined at the mid-line of the head.

Distribution.— The range of *T. brasiliensis* extends from southern and central South America, northward along the west coast of South America, through Central America and Mexico, across the southern half of the United States (Wilkins, 1989). In BBRSP, *T. brasiliensis* was recorded from scattered localities throughout the park (Fig. 22).

Natural History.— With a relative abundance index of 0.228, *T. brasiliensis* was the third most frequently encountered bat at BBRSP. It accounted for 13.7 percent of all bats netted. This bat is reported as the most common bat in lowland areas of the Trans-Pecos (Schmidly, 1977*a*). My results indicate that *T. brasiliensis* is common, but not extremely abundant in the park.

At BBRSP, *T. brasiliensis* frequently was taken along water courses in both densely and sparsely vegetated areas. This bat often was associated with rocky canyons. A large colony uses the ceiling areas of Fort Leaton as a summer roost. This structure lies outside the boundaries of BBRSP, but serves as a visitor's center for the park. An additional large colony roosts under the Fresno Creek Bridge year round. This structure also lies outside the park. Other than in buildings and

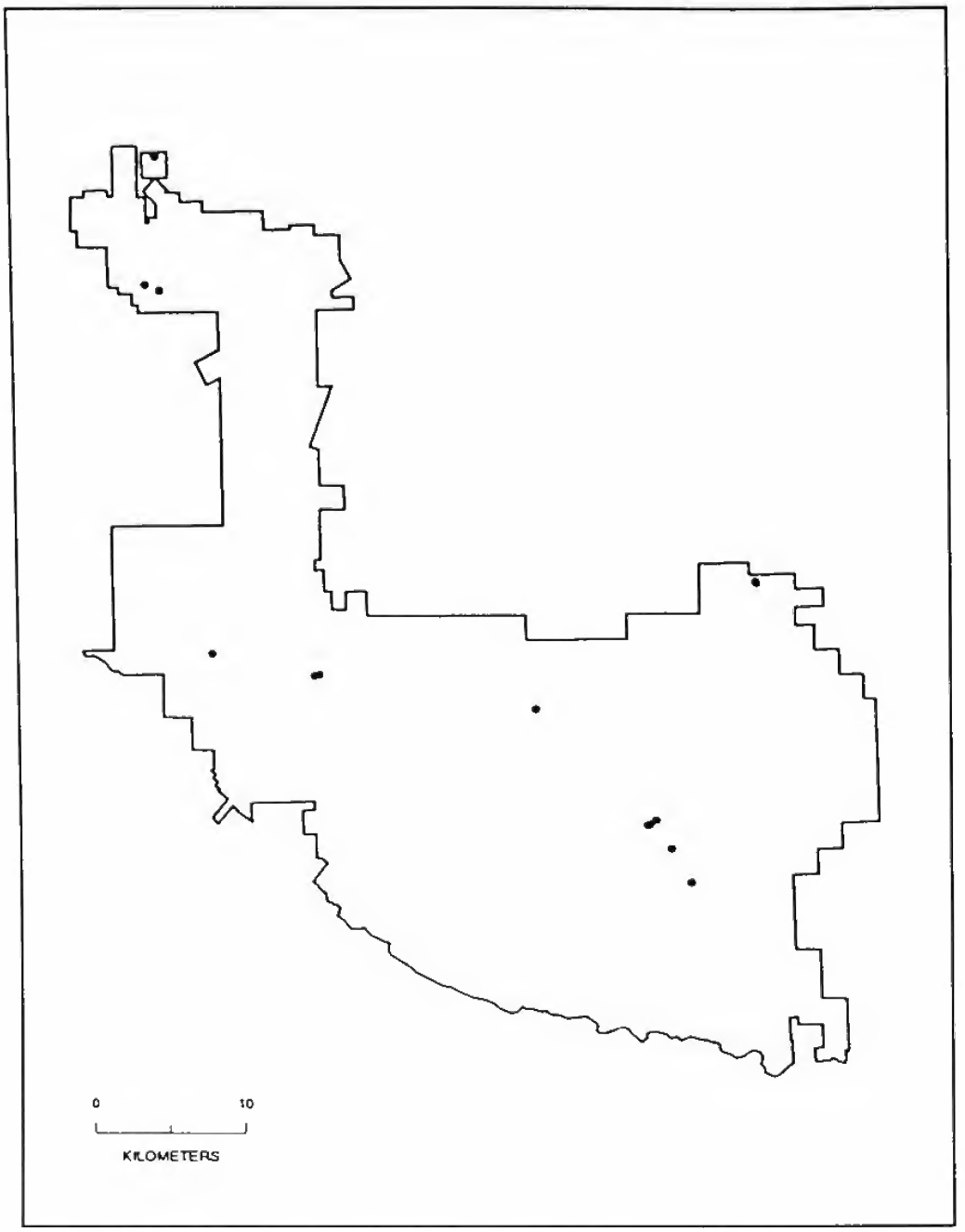

Figure 22. Localities of known specimens of *Tadarida brasiliensis* from Big Bend Ranch State Park, Texas.

under bridges, this bat also may roost in caves (Wilkins, 1989).

In the Trans-Pecos, *T. brasiliensis* is highly migratory, arriving in the area in March and departing in November (Schmidly, 1977*a*). This bat was taken in BBRSP from 20 March through 9 November. There are rare winter records of *T. brasiliensis* hibernating in the Trans-Pecos (Schmidly, 1977*a*), including the Fresno Creek Bridge colony, therefore, this bat should be considered a potential, year round resident in BBRSP.

The reproductive activities of *T. brasiliensis* in the Trans-Pecos are not well understood. Females are

thought to segregate themselves from males in early summer and form large maternity colonies outside the Trans-Pecos. Only males and nongravid females are thought to reside in the Trans-Pecos throughout the summer (Schmidly, 1977*a*). There are rare records of pregnant females in Big Bend National Park in June, but these were considered late migrants through the area (Easterla, 1973). The situation appears to be similar at BBRSP. I examined 7 gravid females taken between 30 April and 7 June, all of which were carrying a single embryo. Pregnant females (with crown-rump length of embryo in parentheses) were examined on the following dates: 30 April (3, 3), 14 May (6), 20 May (11, 12), and 7 June (20, 21). Lactating females were not observed. Both sexes were noted in the park from 20 March to 7 June. From the remainder of June to late July, only males were taken. Both sexes were observed again during the fall months. However, a single volant juvenile was observed on 2 August. This seems rather early for a migrant bat to be passing through, and suggests that possibly a few females give birth in the area.

T. brasiliensis is known to forage in small groups (Ross, 1967) at low to high altitudes over streams, ponds, and cattle watering tanks (Humphrey, 1982). Reported prey items in order of importance include lepidopterans, hymenopterans, coleopterans, homopterans, and hemipterans (Ross, 1967).

Other species of bats taken in sympatry with *T. brasiliensis* at BBRSP included *Mormoops megalophylla*, *Myotis californicus*, *M. thysanodes*, *M. velifer*, *M. yumanensis*, *Pipistrellus hesperus*, *Eptesicus fuscus*, *Lasiurus cinereus*, *Plecotus townsendii*, *Antrozous pallidus*, and *Nyctinomops macrotis*.

Undetermined species of mites and fleas were observed infesting *T. brasiliensis* from BBRSP. In addition, to mites and fleas, other ectoparasites known from this bat include ticks (Wilkins, 1989) and nycteribiid bat flies (Whitaker and Easterla, 1974). Endoparasites recorded from Brazilian free-tailed bats include protozoans, trematodes, and nematodes. This bat frequently has been associated with rabies (Wilkins, 1989), and the incidence of infection in Texas has been reported as high as 24 percent (Schmidly, 1991). Nine specimens from BBRSP were tested for rabies, and all proved negative (Yancey et al., 1997). Other human pathogens harbored by *T. brasiliensis* include Rio Bravo, St. Louis encephalitis, eastern equine encephalitis, western equine encephalitis, and Japanese B encephalitis viruses (Wilkins, 1989). In addition, *Trypanosoma cruzi*, the protozoan that causes Chaga disease, has been recorded in *T. brasiliensis* from the Trans-Pecos (Ubelaker, 1970). *T. brasiliensis* also has been associated with the fungus *Histoplasma capsulatum* (Wilkins, 1989).

Comments.— The subspecies of *T. brasiliensis* at BBRSP is *T. b. mexicana* (Saussure, 1860). The etymology of the generic name *Tadarida* is uncertain. It possibly was derived from the Greek "ta darida," which translates to long ones. The specific epithet *brasiliensis* refers to of Brazil (Stangl et al., 1993).

Specimens Examined (62).— Presidio Co.: BBRSP, UTM coordinates: 13 576060E 3288074N, 1; BBRSP, UTM coordinates: 13 576783E 3296292N, 2; BBRSP, UTM coordinates: 13 576808E 3296211N, 1; BBRSP, UTM coordinates: 13 577000E 3287710N, 2; BBRSP, UTM coordinates: 13 580196E 3264339N, 1; BBRSP, UTM coordinates: 13 586937E 3262923N, 5; BBRSP, UTM coordinates: 13 587263E 3263005N, 2; BBRSP, UTM coordinates: 13 601335E 3260787N, 1; BBRSP, UTM coordinates: 13 608477E 3253180N, 5; BBRSP, UTM coordinates: 13 608608E 3253227N, 6; BBRSP, UTM coordinates: 13 608955E 3253483N, 7; BBRSP, UTM coordinates: 13 609027E 3253496N, 1; BBRSP, UTM coordinates: 13 611283E 3249529N, 1; BBRSP, UTM coordinates: 13 615525E 3268958N, 1; BBRSP, UTM coordinates: 13 615565E 3268878N, 3; BBRSP, UTM coordinates: 13 615599E 3268863N, 15; BBRSP, Arroyo Segundo, 6 (SRSU); BBRSP, Smith Ranch, Fresno Canyon, 2 (SRSU).

Nyctinomops macrotis (Gray, 1839)
Big Free-tailed Bat

Description.— *Nyctinomops macrotis* is a large bat with dark brown to dark gray dorsal pelage. As in all molossids, the posterior third of the tail of *N. macrotis* extends beyond the trailing edge of the uropatagium.

The base of the large, broad ears of this bat are joined near the midline of the head. Vertical folds are present on the lateral sides of the lips. The dental formula for *N. macrotis* is: i 1/2, c 1/1, p 2/2, m 3/3, total 30.

External and cranial measurements of a single adult female from BBRSP are: total length, 130; length of tail vertebrae, 50; length of hind foot, 10; length of ear from notch, 31; weight, 28 (gravid); greatest length of skull, 23.56. Males seem to average slightly larger than females (Milner et al., 1990).

N. macrotis might be confused with the other two species of free-tailed bats that occur at BBRSP. It can be differentiated from *Tadarida brasiliensis* as described in the account for that species. It can be distinguished from *Eumops perotis* by its smaller size, and the presence of vertical folds on the lateral sides of the lips.

Distribution.— *N. macrotis* ranges from the northern two thirds of South America, northward through Central America and Mexico, on into the southwestern United States (Milner, et al., 1990). In BBRSP, *N. macrotis* is known only from Arroyo Segundo (Fig. 23).

Natural History.— Only a single specimen of *N. macrotis* was acquired during my field work at BBRSP. This resulted in a relative abundance index of 0.003. This bat accounted for only 0.2 percent of all bats netted. These results suggest that *N. macrotis* is extremely rare in BBRSP. Interestingly, some 20 years earlier, Scudday (1976*b*) found this bat to be fairly common in Arroyo Segundo. In a five-year study at Big Bend National Park, this bat was found to be rare in most areas, but yearly fluctuations in population numbers were noted. Elsewhere in the state, *N. macrotis* is considered uncommon (Easterla, 1973).

In BBRSP, *N. macrotis* is known only from Arroyo Segundo. This is a deep canyon formed by sheer, rocky cliffs. A small stream and several pools of water occur at the bottom of the canyon. Associated vegetation is dominated by willow and cottonwood, but, in most areas, the water is unobstructed by vegetation. In addition to rugged, rocky arroyos, *N. macrotis* also is known to inhabit desert shrublands and woodlands (Easterla, 1973). In Big Bend National Park, this bat is known to roost in rock crevices (Borell and Bryant, 1942), but also may roost in caves, tree holes, and buildings (Milner et al., 1990). It may roost singly, or in small groups of up to 150 individuals (Milner et al., 1990).

The one specimen acquired during this field work was taken in May. Other specimens have been taken from BBRSP in June. In Big Bend National Park, *N. macrotis* has been recorded from 10 June to 9 September. Winter tendencies of this bat are unknown, but Easterla (1973) and Schmidly (1991) speculate that it may hibernate in the Trans-Pecos, and therefore should be considered a possible year round resident of BBRSP.

At the beginning of summer, the sexes segregate, and females form nursery colonies (Barbour and Davis, 1969; Schmidly, 1977*a*). On 20 May, I examined a pregnant female carrying one embryo (crown-rump length, 12). Easterla (1973) observed gravid females in Big bend National Park from 10 June to 7 July, all of which carried one embryo. He noted lactating females between 27 June and 30 August, and volant juveniles as early as 8 August. These data indicate that in the Big Bend area, females give birth to one young in June or July, as suggested by Easterla (1973) and Schmidly (1991).

The specimen taken during this study was netted late at night, and this was the norm for individuals captured at Big Bend National Park. However, on rare occasions, this bat has been taken before dark. It tends to forage primarily on large lepidopterans, but orthopterans, hymenopterans, and hemipterans occasionally are taken (Easterla, 1973).

Other species of bats taken at the same locality as *N. macrotis* at BBRSP included *Mormoops megalophylla*, *Myotis yumanensis*, *Pipistrellus hesperus*, *Eptesicus fuscus*, *Antrozous pallidus*, and *Tadarida brasiliensis*.

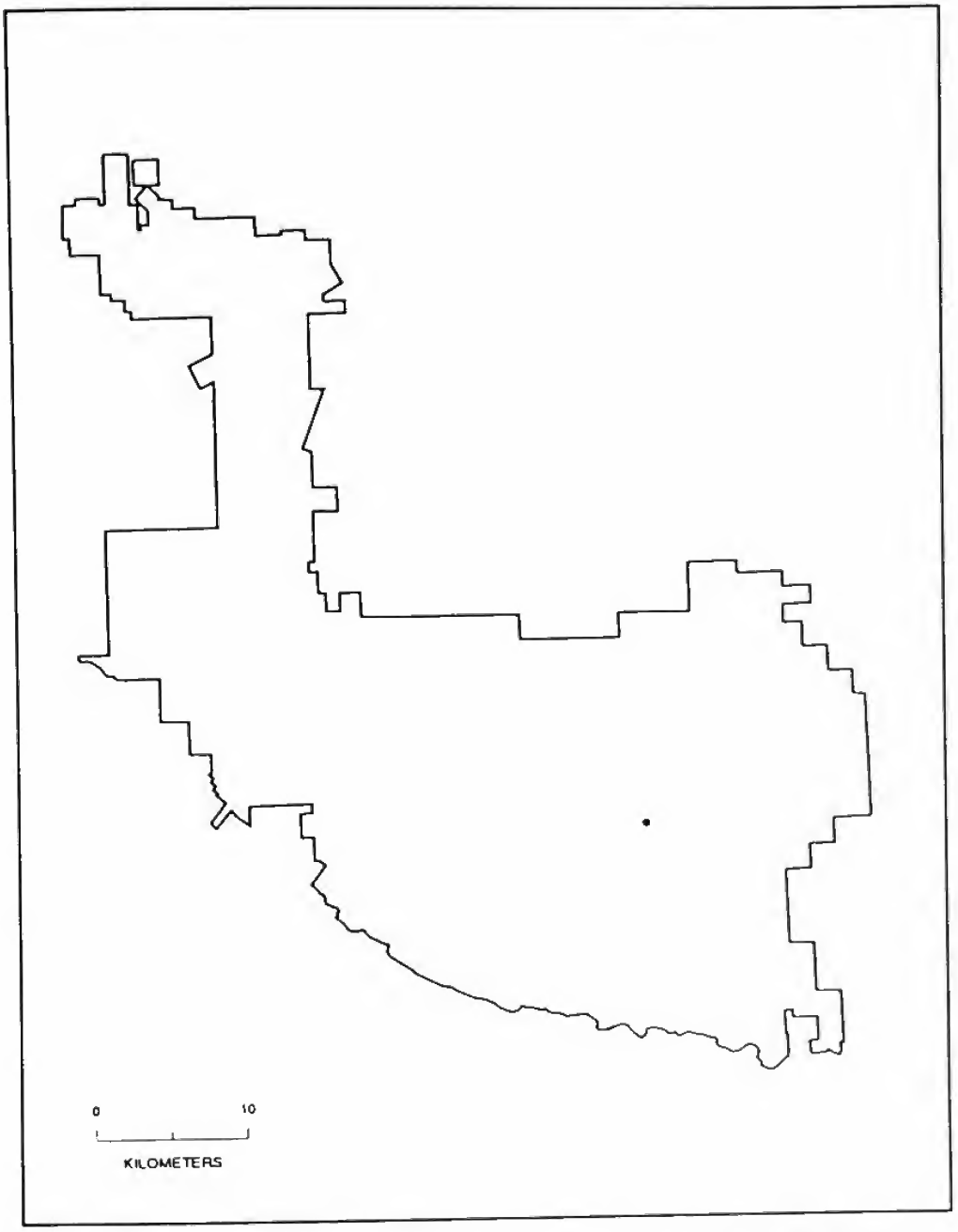

Figure 23. Localities of known specimens of *Nyctinomops macrotis* from Big Bend Ranch State Park, Texas.

No parasites were observed in association with the specimen of *N. macrotis* taken during this study. Ectoparasites known to infest this bat include mites, ticks, and fleas (Milner et al., 1990). The only reported internal parasite of *N. macrotis* is a nematode (Silva Taboada, 1979). *N. macrotis* has been known to be infected with rabies, but no specimens from BBRSP were tested for this virus.

Comments.— *N. macrotis* is a monotypic species. The generic name *Nyctinomops* is derived from the Greek "nyktios," "nomos," and "ops," which translate to night, custom of grazing, and face, respectively. The specific epithet *macrotis* is from the Greek "makros" and "ous" meaning long and ear, respectively (Stangl et al., 1993).

Specimens Examined (2).— Presidio Co.: BBRSP, UTM coordinates: 608608E 3253227N, 1; BBRSP, Arroyo Segundo, 1 (SRSU).

Eumops perotis (Schinz, 1821)
Western Mastiff Bat

Description.— *Eumops perotis* is the largest bat that occurs at BBRSP. Its dorsal pelage is dark gray. As in other molossids, the posterior third of the tail of *E. perotis* extends beyond the trailing edge of the uropatagium. The ears of this bat are large and broad, and are joined at the base near the midline of the head. The lips lack vertical folds. The dental formula for *E. perotis* is: i 1/2, c 1/1, p 2/2, m 3/3, total 30.

No measurements of *E. perotis* from BBRSP were obtained. Schmidly (1991) lists the following average external measurements for this species in general: total length, 171; length of tail vertebrae, 57; length of hind foot, 17; length of ear from notch, 40; weight, 65. Hall (1981) lists the range for greatest length of skull measurements as 30.0-32.9. I know of no reports pertaining to secondary sexual dimorphism in this bat.

E. perotis can be distinguished easily from the other free-tailed bats that occur at BBRSP as described in the two previous accounts.

Distribution.— *E. perotis* ranges from Central Mexico, northward across extreme southwestern Texas, northwestward across the far southwestern United States, into central California (Hall, 1981). In BBRSP, *E. perotis* is known only from Arroyo Segundo (Fig. 24).

Natural History.— *E. perotis* was not taken during this study, and therefore no relative abundance index was calculated. However, as with *Nyctinomops macrotis*, *E. perotis* was reported as fairly common in Arroyo Segundo about 20 years prior to this study (Scudday, 1976*b*). Significant annual fluctuations in abundance of this bat were noted at Big Bend National Park, as no bats were acquired during one year, and 31 were taken the following year (Easterla, 1973).

All specimens of *E. perotis* known from within the boundaries of BBRSP were acquired from Arroyo Segundo. See the previous account for a description of this area. In addition, there is a record of *E. perotis* taken from the Fresno Mine (Eads et al., 1957), which is situated to the east of Whitroy Mine, just outside the eastern park boundary. The habitat in this area is desert scrub dominated by creosote-bush. *E. perotis* is known from a third site in the vicinity of BBRSP based on a specimen housed in the mammal collection at Sul Ross State University. The locality on this specimen simply is "Casa Piedra Road." This road traverses the southwest edge of the park, but the majority of the road lies outside park boundaries. The habitat along most of the road is creosote-bush scrub. *E. perotis* usually roosts in small colonies (2-100 individuals) within rock crevices situated high on cliffs. Roosts must be positioned to allow at least a three-meter unobstructed drop, which is required to initiate flight (Schmidly, 1991).

Records of *E. perotis* from BBRSP exist only from July. However, this bat was observed near Candelaria, Presidio County, during January, February, May, June, July, August, September, and November (Ohlendorf, 1972), indicating that *E. perotis* is a year round resident of the area.

The reproductive biology of *E. perotis* from the Trans-Pecos is poorly known. Males and females continue to use the same roosts while young are born and raised (Schmidly, 1991). In Big Bend National Park, pregnant females were noted between 10 and 27 June, and lactating females were observed from 22 June to 7 August. Volant juveniles were first recorded on 30 August (Easterla, 1973). Apparently a single young is born during June or July.

E. perotis begins foraging late in the night (Schmidly, 1991). It preys primarily upon large lepidopterans, but orthopterans, hymenopterans, coleopterans, odonatans, and homopterans also are consumed (Ross, 1967; Easterla and Whitaker, 1972; Schmidly, 1991).

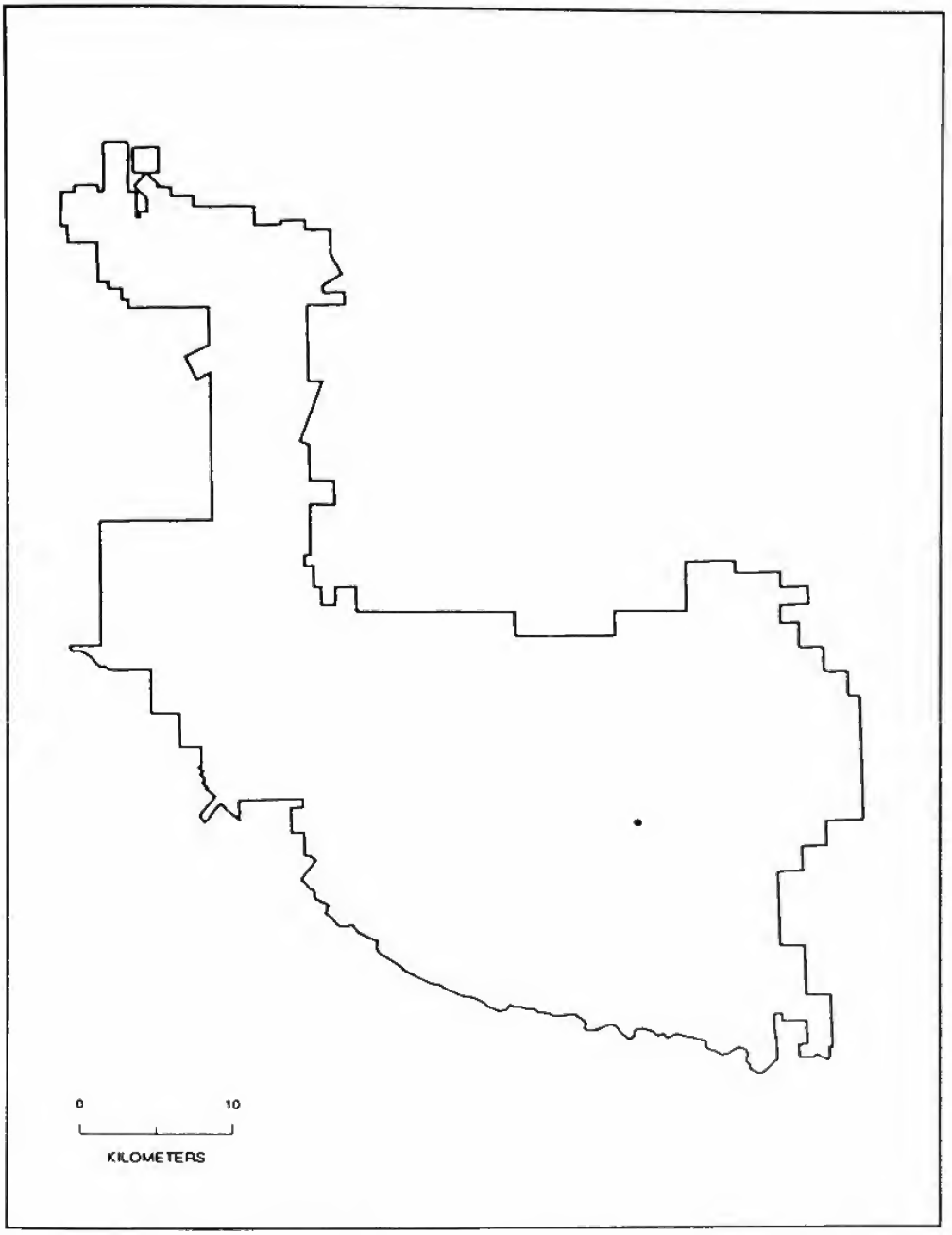

Figure 24. Localities of known specimens of *Eumops perotis* from Big Bend Ranch State Park, Texas.

Because *E. perotis* was not captured during my field work, no comments on associated species can be made. However, the following species of bats were acquired from the same general area from which *E. perotis* was taken previously: *Mormoops megalophylla*, *Myotis thysanodes*, *M. yumanensis*, *Pipistrellus hesperus*, *Eptesicus fuscus*, *Antrozous pallidus*, *Tadarida brasiliensis*, and *Nyctinomops macrotis*.

E. perotis is known to harbor the rabies virus (Constantine, 1988), but no specimens from BBRSP have been tested.

Comments.— The subspecies of *E. perotis* at BBRSP is *E. p. californicus* (Merriam, 1890). The generic name *Eumops* is derived from the Greek "eu"

and the Malay "mops," which translate to good or true, and name of a bat, respectively. The specific epithet *perotis* is from the Greek "peros" and "ous" meaning maimed and ear, respectively (Stangl et al., 1993).

Specimens Examined (3).— Presidio Co.: BBRSP, Arroyo Segundo, 3 (SRSU).

ORDER LAGOMORPHA—LAGOMORPHS

Family Leporidae (Rabbits and Hares)

Sylvilagus audubonii (Baird, 1858)
Desert Cottontail

Description.— *Sylvilagus audubonii* is a small to medium-sized rabbit with dark buffy-brown dorsal pelage that is frosted with black. The ears are moderately long, and the tail is buffy-gray above and white below. The dental formula for *S. audubonii* is: i 2/1, c 0/0, p 3/2, m 3/3, total 28.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 346.8 (8, 280-415, 45.2); length of tail vertebrae, 39.8 (8, 32-52, 7.1); length of hind foot, 87.5 (8, 78-101, 8.1); length of ear from notch, 69.4 (8, 62-79, 5.7); weight, 804 (5, 600-1210, 243.2); greatest length of skull, 66.18 (6, 61.86-74.95, 4.64). Females are slightly larger than males (Orr, 1940).

The only other mammal known from BBRSP that *S. audubonii* might be mistaken for is *Lepus californicus*. Differences are as follows: *S. audubonii* is significantly smaller in size than *L. californicus*, the ears of *S. audubonii* are much shorter (less than 85) than those of *L. californicus* (greater than 115), and the underside of the tail of *S. audubonii* is pure white, whereas that of *L. californicus* is mottled gray.

Distribution.— *S. audubonii* ranges from central Mexico, northward throughout the western half of the United States, except for the Pacific Northwest (Chapman and Willner, 1978). In BBRSP, specimens of this rabbit are known from the Cienega and Las Quevas areas, as well as from the Solitario and the Rio Grande Corridor (Fig. 25). Furthermore, desert cottontails were sighted throughout the entire park.

Natural History.— During this study, eight specimens of *S. audubonii* were collected, and several other individuals were sighted throughout the park. This rabbit should be considered both common and widespread in BBRSP.

Desert cottontails favor desert scrub habitats (Schmidly, 1977*a*). At BBRSP, it was taken in this type of habitat, but also was acquired from riparian woodlands. In addition, it frequently was observed in grasslands and occasionally in juniper woodlands. Therefore, *S. audubonii* should be considered an inhabitant of all major habitat types at BBRSP.

The desert cottontail is active year round, but was taken in BBRSP only during April, June, and July. However, it was sighted throughout the year.

The breeding season of *S. audubonii* varies throughout its range (Chapman et al., 1982). In Texas, mating begins in February (Chapman and Morgan, 1974) and continues throughout most of the year (Davis and Schmidly, 1994). Females give birth to one to six (mean, 2.6) young, two or more times a year (Chapman and Morgan, 1974; Davis and Schmidly, 1994). Two gravid females were examined during this study. One carried three embryos (crown-rump length, 30) on 29 April, and the other was pregnant with two embryos (crown-rump length, 12) on 3 June. Measurements of testes of adult males were as follows: 5 June, 43 X 16; 1 July, 36 X 14; 3 July, 28 X 10; 27 July, 42 X 15. A juvenile that was killed by a western diamondback rattlesnake (*Crotalus atrox*) was collected on 22 July.

Desert cottontails most often were observed foraging during the evening or at night, but frequently were sighted during the daytime as well. This rabbit was seen foraging on grasses, and also is known to feed on

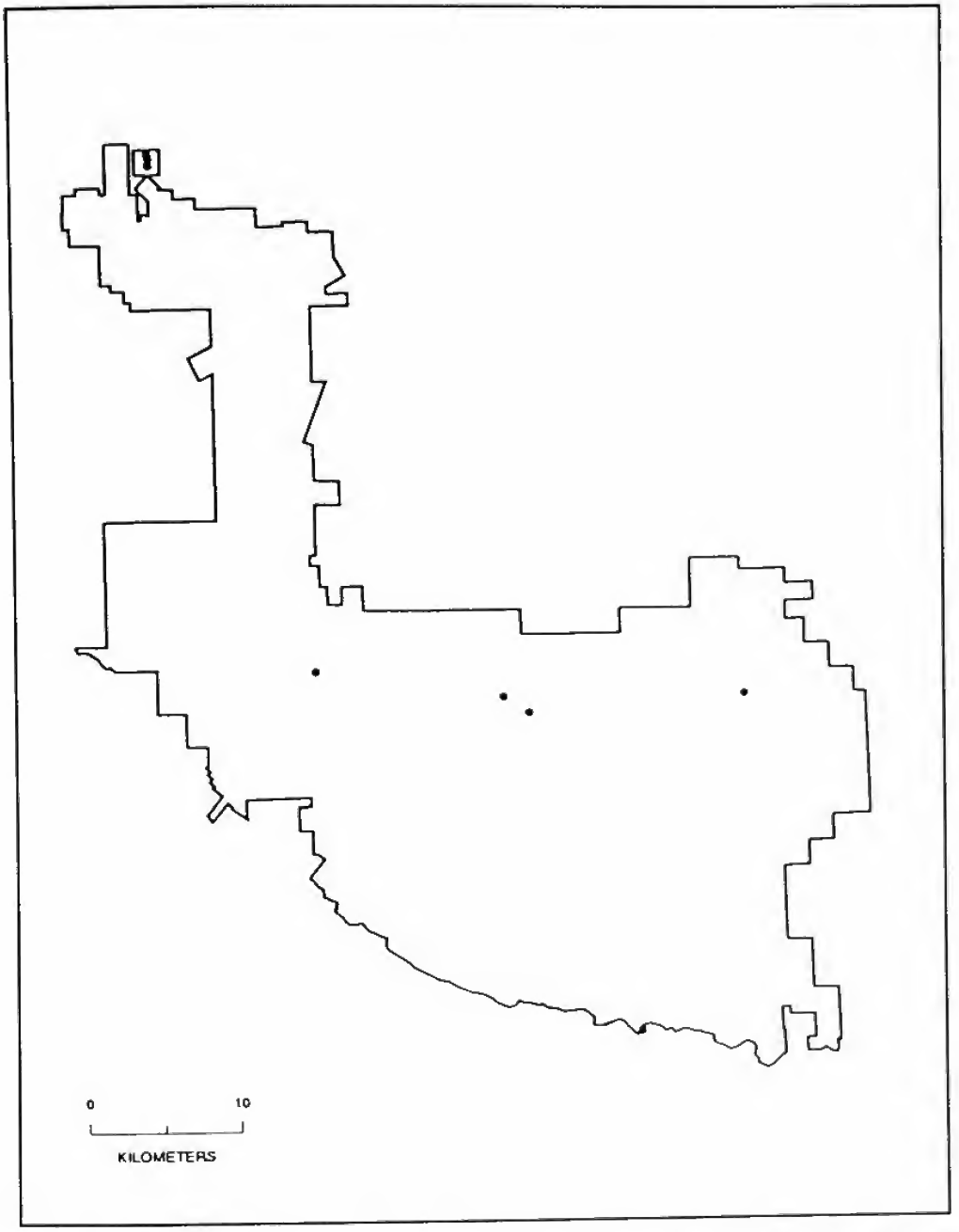

Figure 25. Localities of known specimens of *Sylvilagus audubonii* from Big Bend Ranch State Park, Texas.

the pods and leaves of mesquite, the woody parts of shrubs, and the pads of prickly pear cactus (Davis and Schmidly, 1994).

Seasonal molt occurs twice a year in *S. audubonii*. The first molt begins in late spring or summer, and the second occurs in the fall (Jones et al., 1983). During this study, molting adults were observed in April, June, and July.

No parasites were observed in association with *S. audubonii* at BBRSP. Ectoparasites reported previously include ticks, fleas, and botfly larvae (Chapman and Willner, 1978; Jones et al., 1983). Internal para-

sites known to infect *S. audubonii* include protozoans (Fitch, 1947), cestodes, and nematodes (Chapman and Willner, 1978). Desert cottontails commonly are infected with *Francisella tularensis*, the bacterium that causes tularemia (Gage et al., 1995). Other than humans, *S. audubonii* is the only non-rodent mammal known to be infected with hantavirus (Stone, 1993).

Comments.— The subspecies of *S. audubonii* at BBRSP is *S. a. minor* (Mearns, 1896). The generic name *Sylvilagus* is derived from the Latin "silva" and Greek "lagos," which translate to forest and hare, respectively. The specific epithet *audubonii* refers Audubon's (Stangl et al., 1993).

Specimens Examined (9).— Presidio Co.: BBRSP, UTM coordinates: 13 576329E 3296134N, 1; BBRSP, UTM coordinates: 13 576855E 3295469N, 1; BBRSP, UTM coordinates: 13 576866E 3295865N, 2; BBRSP, UTM coordinates: 13 587281E 3262891N, 1; BBRSP, UTM coordinates: 13 599525E 3261240N, 1; BBRSP, UTM coordinates: 13 601203E 3260197N, 1; BBRSP, UTM coordinates: 13 608309E 3239482N, 1; BBRSP, McGurk's Tank, the Solitario, 1 (SRSU).

Lepus californicus (Gray, 1837)
Black-tailed Jackrabbit

Description.— *Lepus californicus* is a large hare with dark buffy-gray dorsal pelage that is washed with black. The ears are noticeably long, and the tail is topped with a mid-dorsal black stripe that extends onto the rump. The dental formula for *L. californicus* is: i 2/1, c 0/0, p 3/2, m 3/3, total 28.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 532.9 (10, 495-579, 24.5); length of tail vertebrae, 65.9 (10, 57-77, 7.5); length of hind foot, 124.7 (10, 115-130, 4.5); length of ear from notch, 137.6 (10, 128-148, 5.1); weight, 2400 (9, 2100-2700, 200); greatest length of skull, 95.34 (9, 93.67-98.37, 1.55). Female black-tailed jackrabbits are slightly larger than males (Nelson, 1909; Dunn et al., 1982).

The only other mammal that occurs at BBRSP that *L. californicus* might be confused with is *Sylvilagus audubonii*. See the previous account for differentiation.

Distribution.— The range of *L. californicus* extends from central Mexico, northward throughout most of the western half of the United States (Hall, 1981). At BBRSP, specimens of *L. californicus* are known from the Cienega, Terneros Creek, and Sauceda areas, as well as from the north rim of the Solitario (Fig. 26). However, this lagomorph was sighted in all areas of the park except along the Rio Grande.

Natural History.— Schmidly (1977*a*) considered *L. californicus* to be among the commonest of mammals occurring in the Trans-Pecos. Ten specimens of *L. californicus* were collected at BBRSP. In addition, there were countless sightings of this hare throughout this study. Based on these observations, *L. californicus* should be considered abundant in BBRSP.

At BBRSP, black-tailed jackrabbits were taken in both desert scrub and grassland, their preferred habitats (Schmidly, 1977*a*). They were not recorded in riparian habitats. Apparently they avoid such wooded areas because their primary defense mechanisms of exceptional eyesight and escape speed are rendered ineffective (Jones et al., 1985).

L. californicus is active year round, although its abundance may vary by season (Schmidly, 1977*a*). In BBRSP, it was taken during the spring, summer, and fall, and was observed throughout the year.

Black-tailed jackrabbits breed throughout the year. Each year, females give birth to two to six litters, each consisting of one to six young (Davis and Schmidly, 1994). I examined one pregnant female carrying 2 embryos (crown-rump length, 30) on 3 July. Testicular measurements of adult males were as follows: 2 April, 28 X 10, 56 X 21; 13 May, 50 X 15; 23 May, 42 X 23; 1 June, 37; 3 July, 48 X 20; 15 July, 32 X 17; 4 September, 30 X 11; 8 November, 40 X 10.

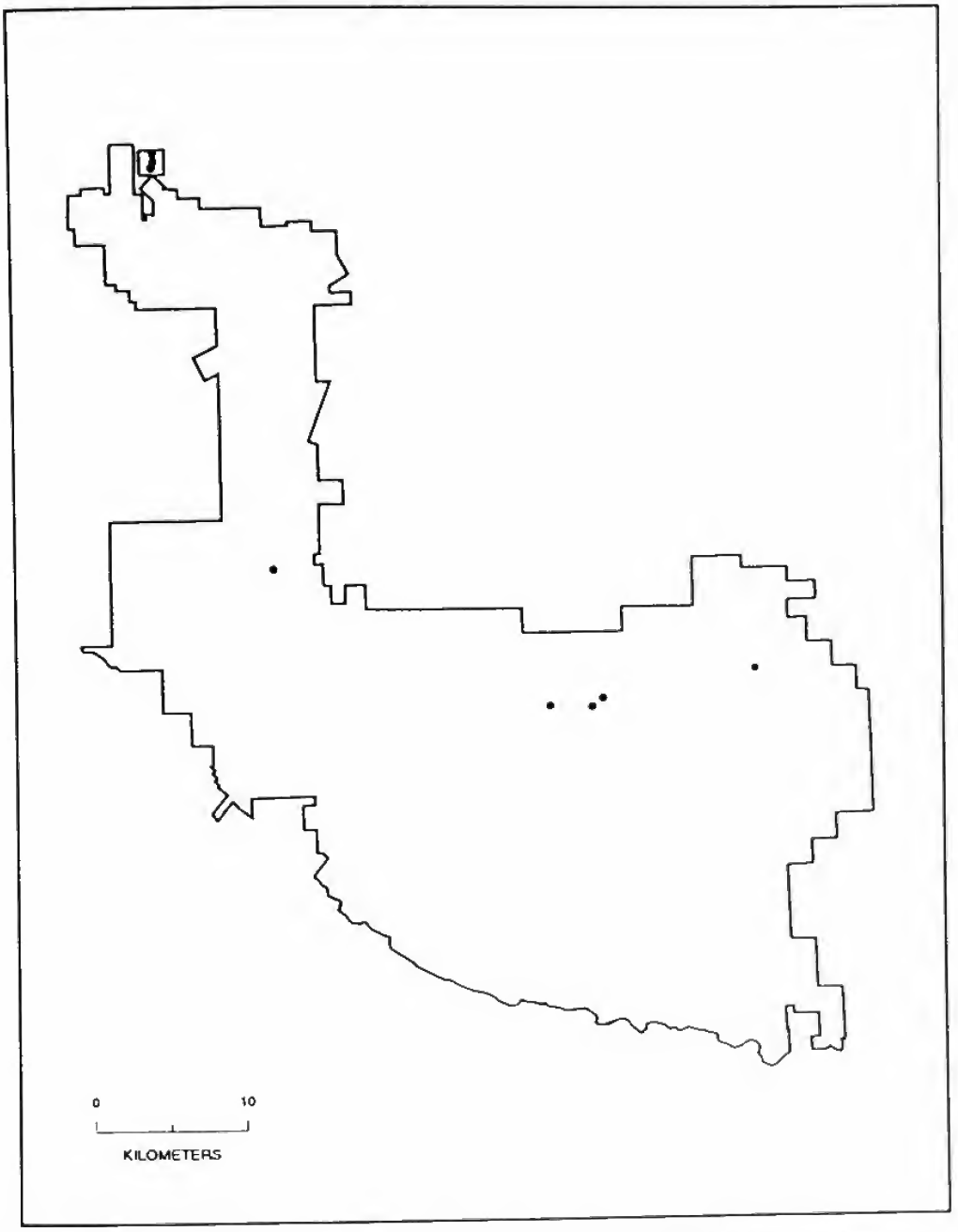

Figure 26. Localities of known specimens of *Lepus californicus* from Big Bend Ranch State Park, Texas.

L. californicus typically forages at night, but occasionally was observed foraging during the daytime. This hare was seen feeding on various grasses and mesquite leaves. In addition, several prickly pear cactus plants showed signs of jackrabbit browsing. Schmidly (1977*a*) reports that *L. californicus* in the Trans-Pecos also consumes sagebrush.

Black-tailed jackrabbits have been reported to undergo one annual molt between August and October (Jones et al., 1983). However, during this study, adults were observed molting in April, June, July, September, and November. These data suggest that at BBRSP, the molting period is longer than reported previously, or that *L. californicus* molts twice a year, once in the spring or summer, and once in the autumn.

External parasites noted on *L. californicus* from BBRSP were ticks and botfly larvae. Other ectoparasites previously reported include mites, lice, and fleas (Jones et al., 1985). Internal parasites found in specimens from BBRSP were limited to tapeworm cysts resembling those of *Taenia serialis*. *L. californicus* has been implicated as a primary reservoir for the pathogenic bacterium *Francisella tularensis*, the etiologic agent of tularemia (Joklik et al., 1980; Jones et al., 1985).

Comments.— The subspecies of *L. californicus* at BBRSP is *L. c. texianus* Waterhouse, 1848. The generic name *Lepus* is Latin for hare. The specific epithet *californicus* refers to of California (Stangl et al., 1993).

Specimens Examined (10).— Presidio Co.: BBRSP, UTM coordinates: 13 576730E 3295308N, 1; BBRSP, UTM coordinates: 13 576796E 3295418N, 1; BBRSP, UTM coordinates: 13 576836E 3296251N, 1; BBRSP, UTM coordinates: 13 576842E 3296279N, 1; BBRSP, UTM coordinates: 13 576872E 3295728N, 1; BBRSP, UTM coordinates: 13 584337E 3269447N, 1; BBRSP, UTM coordinates: 13 602473E 3260516N, 1; BBRSP, UTM coordinates: 13 605201E 3260431N, 1; BBRSP, UTM coordinates: 13 605895E 3261011N, 1; BBRSP, UTM coordinates: 13 615947E 3262894N, 1.

ORDER RODENTIA—RODENTS

Family Sciuridae (Squirrels)

Ammospermophilus interpres (Merriam, 1890)
Texas Antelope Squirrel

Description.— *Ammospermophilus interpres* is a small squirrel with dorsal pelage that is grayish-brown on top, and buff to buffy-brown on the sides. Two narrow white lines that extend from the shoulder to the rump are present, one on each lateral side of the back. The tail hairs are distichous, banded with black and white above, and are creamy white below. The dental formula for *A. interpres* is: i 1/1, c 0/0, p 2/1, m 3/3, total 22.

Means of external and cranial measurements (with sample size and extremes in parentheses) of adult specimens from BBRSP are: total length, 233.3 (3, 222-255); length of tail vertebrae, 76.3 (3, 74-80); length of hind foot, 35.7 (3, 35-37); length of ear from notch, 12.3 (3, 12-13); weight, 98 (3, 97-99); greatest length of skull, 38.85 (2, 37.69-40.00). I know of no reports pertaining to secondary sexual dimorphism in this squirrel.

The presence of two white stripes on the dorsum of *A. interpres* easily distinguishes this squirrel from *Spermophilus spilosoma* and *S. variegatus*, the only other species of squirrels at BBRSP.

Distribution.— The distribution of *A. interpres* extends from southern Coahuila and northeastern Durango, Mexico, northward through eastern Chihuahua, Mexico, and southwestern Texas, and into central New Mexico (Best et al., 1990). In BBRSP, specimens exist from the Bofecillos Mountains area and the Solitario (Fig. 27), but this squirrel also was observed at scattered sites throughout much of the park.

Natural History.— Two specimens of *A. interpres* were collected during this study, and occasionally individuals were sighted. The wary and nervous disposition of this squirrel (Best et al., 1990) hindered efforts to collect and observe them. Therefore, they probably are more abundant than records indicate, but still should be considered uncommon at BBRSP.

Both specimens of *A. interpres* acquired from BBRSP were taken in rocky uplands. The associated vegetation of both sites was grassland with encroaching scrub species. Additional individuals were sighted in similar habitats, as well as in boulder fields and grav-

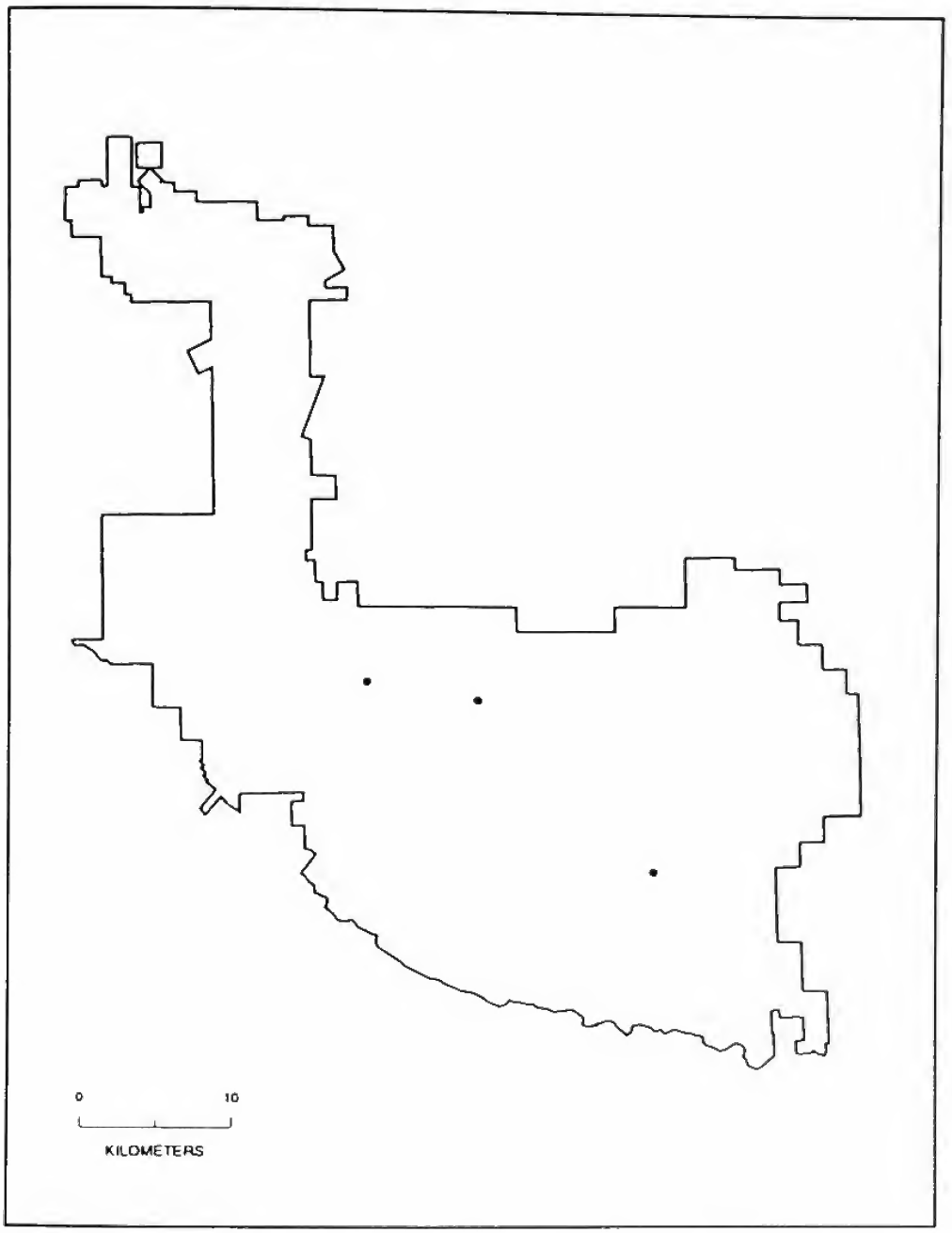

Figure 27. Localities of known specimens of *Ammospermophilus interpres* from Big Bend Ranch State Park, Texas.

elly washes. This squirrel was not noted in level desert scrub or in sandy places, but is known to occur in such areas (Davis and Schmidly, 1994).

During this study, *A. interpres* was taken in February and June. Additional sightings occurred in January, May, June, July, and November. It is thought that this squirrel does not hibernate at low elevations (Davis and Schmidly, 1994); that appears to be the situation at BBRSP.

Data on the reproductive habits of *A. interpres* are wanting. I examined a male taken on 28 February that was in reproductive condition (testes, 17 X 8). This

apparently is about the time the breeding season begins. Typically, females give birth to one litter of five to 14 young per year. However, some females may produce two litters during the same year (Davis and Schmidly, 1994).

Like other squirrels at BBRSP, *A. interpres* is diurnal (Herman, 1950) and is active especially during the hottest part of the day (Blair and Miller, 1949; Baker et al., 1980). This squirrel feeds on a variety of plant material, including the fruits, seeds, and stems of cactus, mesquite beans, creosote-bush seeds, and juniper berries, but insects may be consumed as well (Best et al., 1990).

A. interpres undergoes two annual molts. A spring molt occurs in May and a fall molt takes place in September (Best et al., 1990).

An undetermined species of flea was found infesting *A. interpres* at BBRSP. The only parasite reported previously from this squirrel is a nematode (Baker and Greer, 1962).

Comments.— *A. interpres* is a monotypic species. The generic name *Ammospermophilus* is derived from the Greek "ammos," "sperma," and "philos," which translate to sand, seed, and loving, respectively. The specific epithet *interpres* is Latin for intermediary (Stangl et al., 1993).

Specimens Examined (3).— Presidio Co.: BBRSP, UTM coordinates: 13 591022E 3261963N, 1; BBRSP, UTM coordinates: 13 598198E 3260782N, 1; BBRSP, Madrid Ranch, Chorro Canyon, 15 mi. N Lajitas, 1 (SRSU).

Spermophilus spilosoma
Bennett, 1833
Spotted Ground Squirrel

Description.— *Spermophilus spilosoma* is a small squirrel with a dorsal pelage that is pale brown with numerous faint white spots scattered about. The dental formula for *S. spilosoma* is: i 1/1, c 0/0, p 2/1, m 3/3, total 22.

Means of external and cranial measurements (with sample size and extremes in parentheses) of adult specimens from BBRSP are: total length, 236.0 (2, 233-239); length of tail vertebrae, 77.0 (3, 75-80); length of hind foot, 34.0 (4, 31-36); length of ear from notch, 11.0 (3, 11); weight, 112.3 (3, 100-125); greatest length of skull, 38.69 (2, 37.90-39.48). I know of no reports pertaining to secondary sexual dimorphism in this species.

In BBRSP, *S. spilosoma* may be confused with *S. variegatus* and *Ammospermophilus interpres*. *S. spilosoma* is small and spotted, whereas *S. variegatus* is relatively large, lacks spots, and has a black head. See the previous account for differentiation from *A. interpres*.

Distribution.— *S. spilosoma* ranges from north-central Mexico and South Texas, northward through Texas and the central Plains states and westward to Arizona and Utah (Streubel and Fitzgerald, 1978). In BBRSP, this squirrel is known only from near the west entrance of the park and the Solitario (Fig. 28).

Natural History.— Three specimens of *S. spilosoma* were collected during this study, and one additional individual was sighted. This squirrel is known to be shy (Davis and Schmidly, 1994), which may account, in part, for the infrequent encounters in the park. Nonetheless, given such few observations, *S. spilosoma* should be regarded as uncommon in BBRSP.

The spotted ground squirrel reportedly favors sparsely-vegetated areas with deep, sandy soils (Streubel and Fitzgerald, 1978). However, all individuals taken or observed during this study were in desert scrub dominated by creosote-bush. The substrate in each of these areas was gravelly. Desert scrub with hard substrata was reported as the preferred habitat at Big Bend National Park as well (Schmidly, 1977*a*).

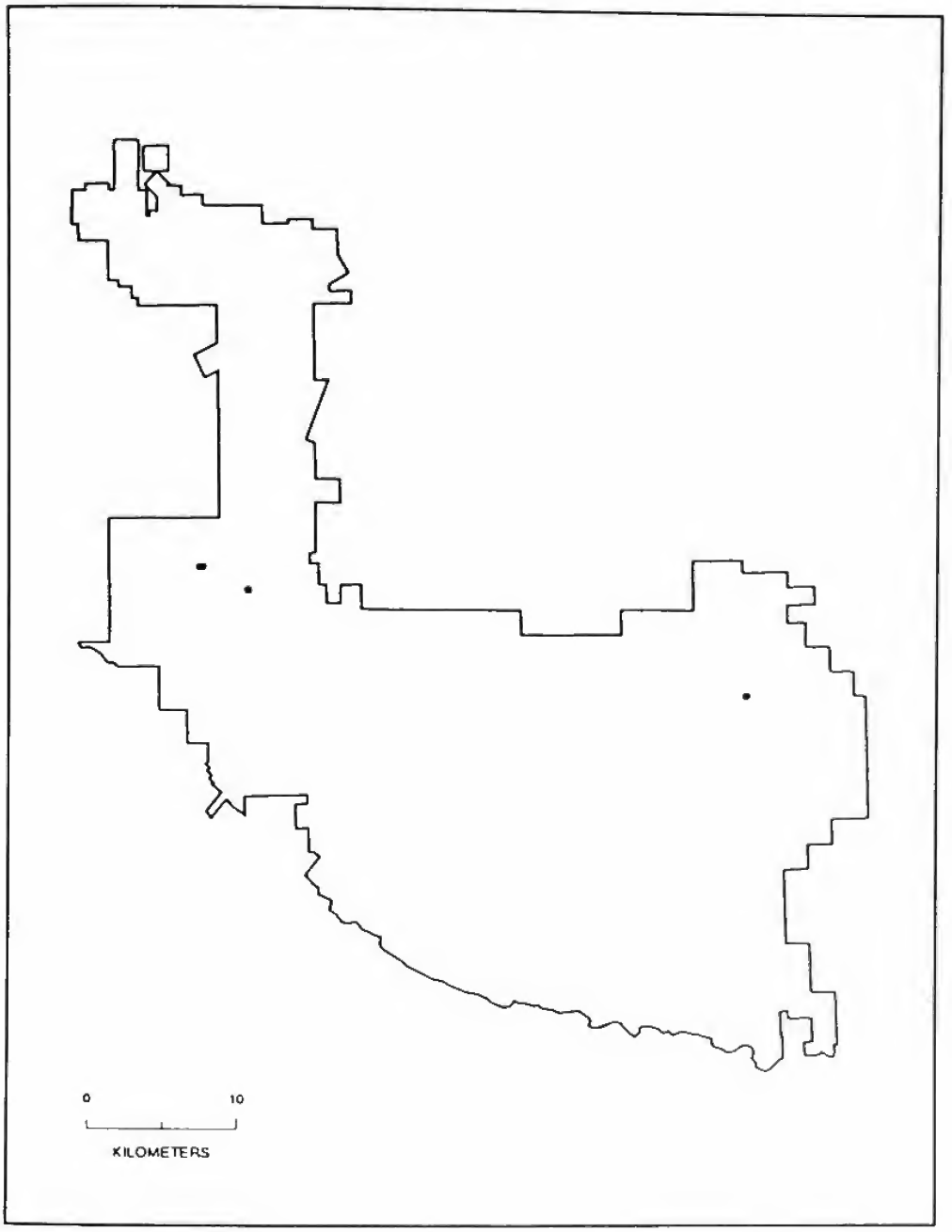

Figure 28. Localities of known specimens of *Spermophilus spilosoma* from Big Bend Ranch State Park, Texas.

S. spilosoma hibernates, to some degree, over the cooler months, but the extent of its hibernating habits are not known (Schmidly, 1977*a*; Streubel and Fitzgerald, 1978; Davis and Schmidly, 1994). I collected a specimen in November, and individuals have been taken during December, January, and February elsewhere in the state (Davis and Schmidly, 1994). This suggests that in Texas, hibernation in *S. spilosoma* is not complete.

The reproductive biology of *S. spilosoma* is poorly known. A male in reproductive condition (testes, 13 X 7) was examined on 14 May, and one in non-reproductive condition (testes, 7 X 4) was noted on 8 Novem-

ber, suggesting that this squirrel breeds during March, but not November. Litter sizes range from five to eight (Asdell, 1964), and it has been suggested that females are diestrous, producing two litters annually (Streubel and Fitzgerald, 1978).

S. spilosoma is diurnal and, in an effort to avoid the mid-day heat, forages in the early morning and late afternoon. It feeds primarily on seeds and other plant material, but also may consume animal matter, including insects, lizards, and even small rodents (Streubel and Fitzgerald, 1978).

Adult spotted ground squirrels molt twice a year. A spring molt occurs by late May, and a second molt, which is not conspicuous in adults, takes place sometime in the fall (Streubel and Fitzgerald, 1978).

S. spilosoma was trapped in association with *Dipodomys merriami* and *Chaetodipus eremicus*.

No parasites were observed in association with *S. spilosoma* from BBRSP. Ticks, biting lice, and fleas are known to infest *S. spilosoma*. Various nematodes are the only reported endoparasites of this squirrel (Streubel and Fitzgerald, 1978).

Comments.— The subspecies of *S. spilosoma* at BBRSP is *S. s. marginatus* Bailey, 1890. The generic name *Spermophilus* is derived from the Greek "sperma" and "philos," which translate to seed, and loving, respectively. The specific epithet *spilosoma* is from the Greek "spilos" and "soma," meaning spot and body, respectively (Stangl et al., 1993).

Specimens Examined (4).— Presidio Co.: BBRSP, UTM coordinates: 13 579684E 3269447N, 1; BBRSP, UTM coordinates: 13 579888E 3269478N, 1; BBRSP, UTM coordinates: 13 582900E 3268000N, 1; BBRSP, McGurk's Tank, the Solitario, 1 (SRSU).

Spermophilus variegatus (Erxleben, 1777)
Rock Squirrel

Description.— *Spermophilus variegatus* is a large squirrel with a dorsal pelage that is black about the head, neck, and upper back, and mottled grayish brown towards the rear. The tail is long and relatively bushy. The dental formula for *S. variegatus* is: i 1/1, c 0/0, p 2/1, m 3/3, total 22.

External measurements of an adult male from BBRSP are: total length, 520; length of tail vertebrae, 248; length of hind foot, 62; length of ear from notch, 25; weight, 959. Males average larger in size than females (Oaks et al., 1987).

Distribution.— *S. variegatus* ranges from central Mexico, northward throughout most of the southwestern United States (Oaks et al., 1987). At BBRSP, this squirrel was collected only from the Rio Grande Corridor (Fig. 29). In addition, it was sighted in scattered localities throughout the park including the Cienega, Sauceda, Botilla, and Lava Canyon areas.

Natural History.— During this study, one specimen of *S. variegatus* was collected, and five additional individuals were sighted. As are the other squirrels in BBRSP, rock squirrels are wary, making them difficult to collect and observe (Oaks et al., 1987). Hence, they may be more common in BBRSP than the frequency of encounters indicates.

All rock squirrels taken and observed at BBRSP were in areas of rock or boulder-associated cliffs, hills, canyons, stream washes, or slopes, its preferred habitats as suggested by its common name (Tomich, 1982; Oaks et al., 1987). In the absence of rocky areas, this squirrel may utilize human structures, such as buildings, bridges, terraced roads, and stone walls (Oaks et al., 1987). Vegetation associated with the rocky areas where *S. variegatus* was observed at BBRSP included, mesquite, creosote scrub, and riparian woodland dominated by willow and cottonwood.

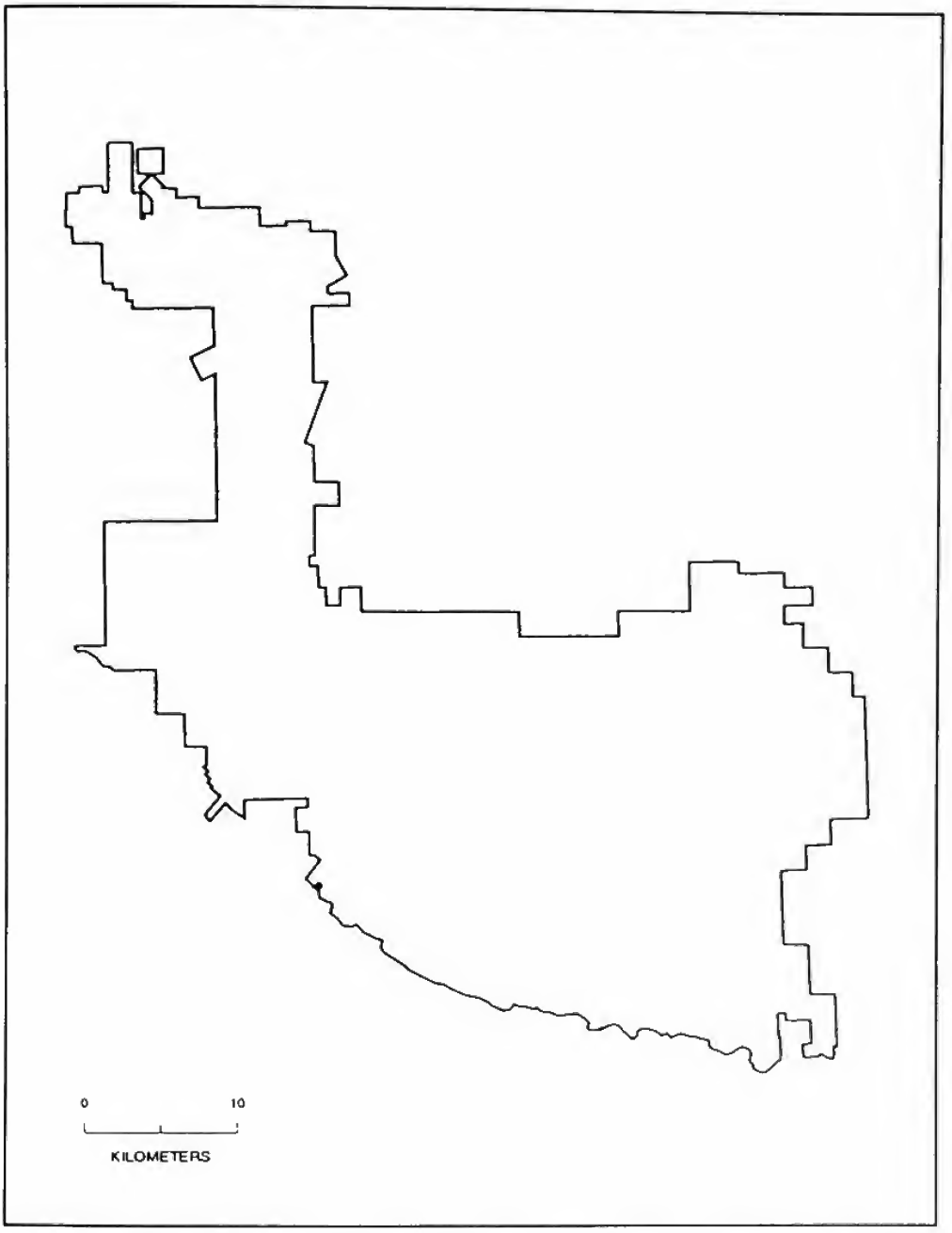

Figure 29. Localities of known specimens of *Spermophilus variegatus* from Big Bend Ranch State Park, Texas.

During this study, rock squirrels were encountered during May, June, July, and October. These squirrels hibernate throughout much of their range, and the absence of observations during the winter months suggests that this might be the situation at BBRSP. However, they have been reported to be active throughout the year at low elevations in the Big Bend area (Davis and Schmidly, 1994). There is evidence that rock squirrels hibernate in response to food shortages, rather than cooler temperatures (Oaks et al., 1987). They are known to store food for winter use (Davis and Schmidly, 1994), and the quantity of food in their winter caches may determine the degree to which this squirrel hibernates. There also is evidence that rock squirrels estivate in parts of their range (Oaks et al., 1987), but occasional summer observations discount this behavior at BBRSP.

The breeding season for *S. variegatus* in the Trans-Pecos has been reported to last from April to June (Schmidly, 1977*a*). However, a male collected on 31 July possessed scrotal testes measuring 40 X 14. The testes of male rock squirrels are scrotal only during the breeding season, at which time their average length is 32. During non-breeding periods, they average only 11 (Oaks et al., 1987). This suggests that the breeding season of rock squirrels at BBRSP extends into late July or early August. Borell and Bryant (1942) suggested that females give birth to at least two litters per year at Big Bend National Park, and multiple litters seem likely at BBRSP given the potential length of the breeding season. Litter sizes range from two to nine (Oaks et al., 1987; Davis and Schmidly, 1994) with a mean of about five (Oaks et al., 1987).

The rock squirrel is diurnal, but the time of peak activity varies by season. In the cooler months, it is most active at mid-day, whereas during the summer, it is more active in the morning and late afternoon. The majority of the daily activities of this squirrel is focused on foraging and feeding. Its diet is highly variable, and fluctuates seasonally (Oaks et al., 1987). The internal cheek pouches of the specimen collected at BBRSP were full of mesquite beans. Other foods consumed by rock squirrels include seeds, grains, fruits, roots, green vegetation, cactus, invertebrates, small vertebrates, and dried meat (Oaks et al., 1987).

Seasonal molting in adult rock squirrels occurs once a year. At BBRSP, this probably occurs around the middle of summer (Oaks et al., 1987).

No parasites were noted in association with the rock squirrel specimen from BBRSP. Known external parasites of *S. variegatus* include mites, ticks, lice, fleas, and fly larvae. Known internal parasites include protozoans, trematodes, cestodes, and several nematodes (Oaks et al., 1987). *S. variegatus* apparently is a reservoir for *Yersinia pestis*, the etiologic agent of plague (Quan et al., 1985). Furthermore, 11 of the 19 species of fleas reported to infest rock squirrels are known vectors of plague. Also, *S. variegatus* is known to harbor *Rickettsia rickettsii*, the causative agent of Rocky Mountain spotted fever. Several of the known ectoparasites of rock squirrels are vectors of tularemia, brucellosis, and Q-fever, however the infection of rock squirrels with these diseases has not been not documented (Oaks et al., 1987)

Comments.— The subspecies of *S. variegatus* that occurs at BBRSP is *S. v. grammurus* (Say, 1823). See the account on *Spermophilus spilosoma* for the etymology of the generic name. The specific epithet *variegatus* is from the Latin "variegare," meaning diversify (Stangl et al., 1993).

Specimens Examined (1).— Presidio Co.: BBRSP, UTM coordinates: 13 587570E 3249037N, 1.

Family Geomyidae (Pocket Gophers)

Thomomys bottae (Eydoux and Gervais, 1836)
Botta's Pocket Gopher

Description.— *Thomomys bottae* is a small to medium-sized gopher with pale brown dorsal pelage. The upper parts of the forefeet are whitish, and the anterior surface of the upper incisors are smooth, lacking conspicuous grooves. The dental formula for *T. bottae* is: i 1/1, c 0/0, p 1/1, m 3/3, total 20.

Means of external measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 205.2 (13, 177-225, 15.2); length of tail vertebrae, 57.9 (13, 48-64, 4.8); length of hind foot, 28.6 (12, 25-33, 2.3); length of ear from notch, 6.6 (11, 5-8, 1.1); weight, 105.8 (5, 92.5-133, 17.9). A single skull was examined, and its greatest length was 36.68. Males of this species tend to be considerably larger than females (Davis and Schmidly, 1994).

T. bottae can be distinguished easily from *Cratogeomys castanops*, the only other pocket gopher at BBRSP, by its small size, pale upper forefeet, and smooth upper incisors. *C. castanops* is considerably

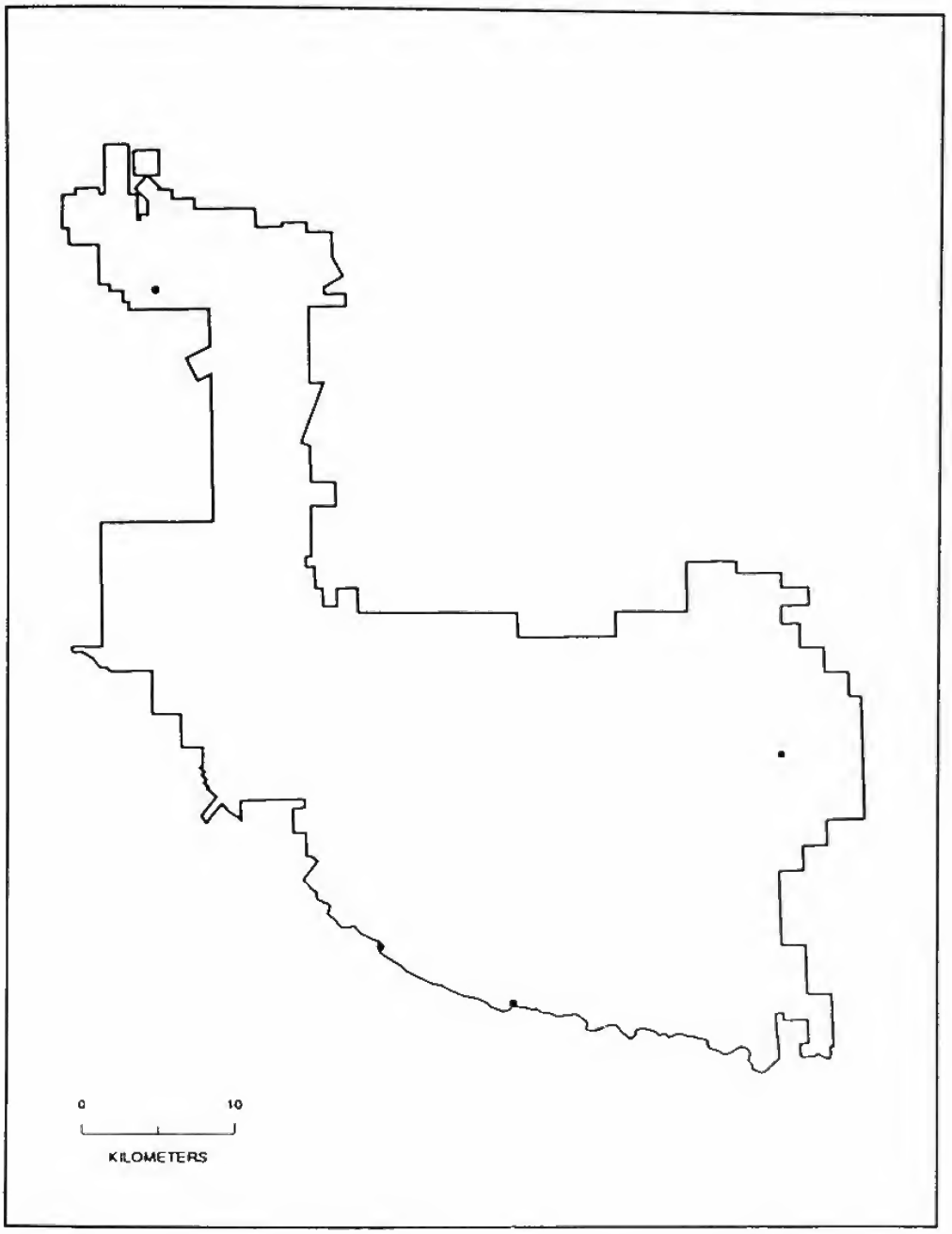

Figure 30. Localities of known specimens of *Thomomys bottae* from Big Bend Ranch State Park, Texas.

larger, has dark upper forefeet, and has a large groove on the anterior surface of each upper incisor.

Distribution.— *T. bottae* ranges from northern Mexico, northward throughout the western United States, excluding the far north (Hall, 1981). In BBRSP, specimens of this gopher are known from the Rio Grande Corridor, the Cienega area, and the Solitario (Fig. 30). In addition, mounds presumably made by *T. bottae* were noted throughout the park in suitable habitats.

Natural History.— Only two specimens of *T. bottae* were acquired during this study. However, numerous sightings of this gopher's mounds indicate that this species is rather common in BBRSP.

T. bottae is very adaptable in terms of habitat requirements (Davis and Schmidly, 1994). During this study, this gopher was taken in water-associated habitat dominated by mesquite and short grass, and in desert grassland with large stands of lechuguilla. *T. bottae* mounds were observed in desert scrub associated with lechuguilla, in riparian areas dominated by willow and cottonwood, and in tamarisk-mesquite associations along the Rio Grande. The substrata where *T. bottae* was noted also were highly variable, ranging from loose sand, to sandy loam, to hard rocky soils.

Botta's pocket gopher is reported to be active year round (Davis and Schmidly, 1994). During this study, *T. bottae* was taken in February and November, and active burrows were noted in May, July, and December. Museum specimens examined were acquired during January, February, and July.

Adult Botta's pocket gophers are solitary except while breeding (Davis and Schmidly, 1994). The breeding season lasts throughout the year, with peaks in reproductive activity in the spring, summer, and early winter. A male in breeding condition (testes, 17 X 12) was taken on 4 November. On average, females give birth to two litters of five young per year (Schmidly, 1977*a*).

T. bottae spends 90 percent of its life in its burrow system. It feeds primarily on fleshy roots and tubers of most native plants. In addition, this gopher is known to clip off and feed on surface vegetation (Davis and Schmidly, 1994). At BBRSP, on several occasions the opening of burrows were filled with clipped lechuguilla stems.

At BBRSP, an adult was observed with molt lines on 4 November. The presence of molt lines on *T. bottae* typically indicates a change from winter to summer pelage. However, a molt line also could be a demarcation between parts of the pelage that molted at different times, a phenomenon not observed in most nonfossorial mammals (Chase et al., 1982).

Other rodents taken from the same localities as *T. bottae* at BBRSP included *Chaetodipus eremicus*, *Dipodomys merriami*, *Peromyscus eremicus*, *P. maniculatus*, *Neotoma albigula*, and *N. mexicana*. Interestingly, *Cratogeomys castanops*, the only other pocket gopher that occurs at BBRSP, was found to occur both sympatrically and syntopically with *T. bottae*. Baker (1956), Reichman and Baker (1972), Schmidly (1977*a*), and Davis and Schmidly (1994) all discussed habitat segregation of *T. bottae* and *C. castanops* where the two species are sympatric. Segregation was thought to be a function of substrate quality. *Cratogeomys* has been reported to exclude *Thomomys* from areas with deep sandy soils and displace it to areas with thin, rocky substrata (Hollander et al., 1987; Hollander, 1990). At BBRSP, sympatric and syntopic occurrence of the two pocket gophers was observed in an area adjacent to Cienega Creek. Vegetation was short grass with scattered mesquite, and the soil was a deep, moist, sandy loam. The site noticeably had been subjected to periodic flooding. At this locality, the two species of pocket gophers were taken within 25 m of one another. Where the two species reside in the same soil and vegetation, the burrows of *T. bottae* are deeper than those of *C. castanops*, thus reducing interspecific encounters (Best, 1973).

No parasites were noted in association with *T. bottae* from BBRSP.

Comments.— Specimens of *T. bottae* from BBRSP are tentatively assigned to *T. b. limitaris* Goldman, 1936. However, the systematic affinities of this gopher in BBRSP are questionable, and require further examination before specimens can be assigned definitively to a subspecies. The generic name *Thomomys* is derived from the Greek "thomos" and "mys," which translate to heap and mouse, respectively. The specific epithet *bottae* refers to Botta's (Stangl et al., 1993).

Specimens Examined (16).— Presidio Co. BBRSP, UTM coordinates: 13 577321E 3287548N, 1; BBRSP, Colorado Canyon, 9 (SRSU); BBRSP, 12 mi. W Lajitas, 5 (SRSU).Brewster Co.: BBRSP, UTM coordinates: 13 618185E 3257611N, 1.

***Cratogeomys castanops* (Baird, 1852)**
Yellow-faced Pocket Gopher

Description.— *Cratogeomys castanops* is a large pocket gopher with a pale to deep brown dorsal pelage. The top of its forefeet usually are dark, and a single, deep groove is present on the anterior surface of each upper incisor. The dental formula for *T. bottae* is: i 1/1, c 0/0, p 1/1, m 3/3, total 20.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 263.3 (4, 250-284, 16.1); length of tail vertebrae, 70.8 (4, 62-75, 6.1); length of hind foot, 33.8 (4, 32-36, 2.1); length of ear from notch, 5.6 (4, 5-6, 0.5); weight, 250.5 (4, 168-400, 102.4); greatest length of skull, 50.68 (3, 46.55-57.71, 6.12). Males are significantly larger than females (Hollander, 1990).

C. castanops may be confused with *Thomomys bottae*, the only other pocket gopher known from BBRSP. The two can be distinguished easily as described in the previous account.

Distribution.— *C. castanops* ranges from north-central and northeastern Mexico, northward through western Texas and eastern New Mexico, and into eastern Colorado, the Oklahoma Panhandle, and western Kansas. Isolated populations occur in southern Texas (Davidow-Henry et al., 1989). In BBRSP, this pocket gopher is known from the Cienega, Sauceda, and Las Quevas areas, as well as from the Barton Warnock Center (Fig. 31).

Natural History.— Four specimens of *C. castanops* were collected during this study, and occasionally mounds of this species were noted. It should be considered widespread, but not common at BBRSP.

C. castanops reportedly favors habitats with deep, sandy soils that are relatively free of rocks, but is known to occur in rocky areas as well (Davidow-Henry et al., 1989; Hollander, 1990). At BBRSP, *C. castanops* was taken in a grassy area with scattered mesquite on a deep, sandy loam substrate, and in desert scrub dominated by creosote-bush, with a hard, gravelly substrate. In addition, this gopher was taken in two artificial habitats; one being the garden at the Barton Warnock Center, and the other the lawn of the "Big House" at Sauceda. The substrate at the former site was hard and rocky, and that at the latter site was a deep, moist, sandy loam. Based on these data, *C. castanops* should be considered somewhat of a habitat generalist at BBRSP.

During this study, *C. castanops* was taken during March, May, and July, but this species is active all year long (Davidow-Henry et al., 1989).

C. castanops is reproductively active throughout the year, with no obvious peaks in activity (Hollander, 1990). During this study, a reproductively active male (testes, 15 X 10) was observed on 17 March, and a lactating female was noted on 26 July. In Texas, gravid females have been taken during every month, with a mean litter size of 2.08 (Hollander, 1990).

The yellow-faced pocket gopher mostly forages from within its burrow system. Plants are pulled into the burrow by their roots, or green vegetation is collected from the burrow opening (Davidow-Henry et al., 1989). Lechuguilla appears to be among the primary plant species consumed (Hermann, 1950).

Birney et al. (1971) reported that adult yellow-faced pocket gophers molt twice a year, once in both spring and early autumn. In contrast, Ikenberry (1964) documented a single, continuous period of molt from August through March. I examined two adult specimens undergoing molt, one taken on 31 May, and the other captured on 26 July. These data appear more consistent with the single continuous molt strategy proposed by Ikenberry (1964).

Other rodents taken in association with *C. castanops* at BBRSP included *Thomomys bottae*, *Chaetodipus eremicus*, and *Peromyscus maniculatus*. See the previous account for a discussion on sympatric relations of *C. castanops* and *T. bottae*.

No parasites were noted in association with yellow-faced pocket gophers from BBRSP. Ectoparasites known to infest *C. castanops* include mites, lice, and fleas (Davidow-Henry et al., 1989).

Comments.— The subspecies of *C. castanops* at BBRSP is *C. c. clarkii* (Baird, 1855). The generic name

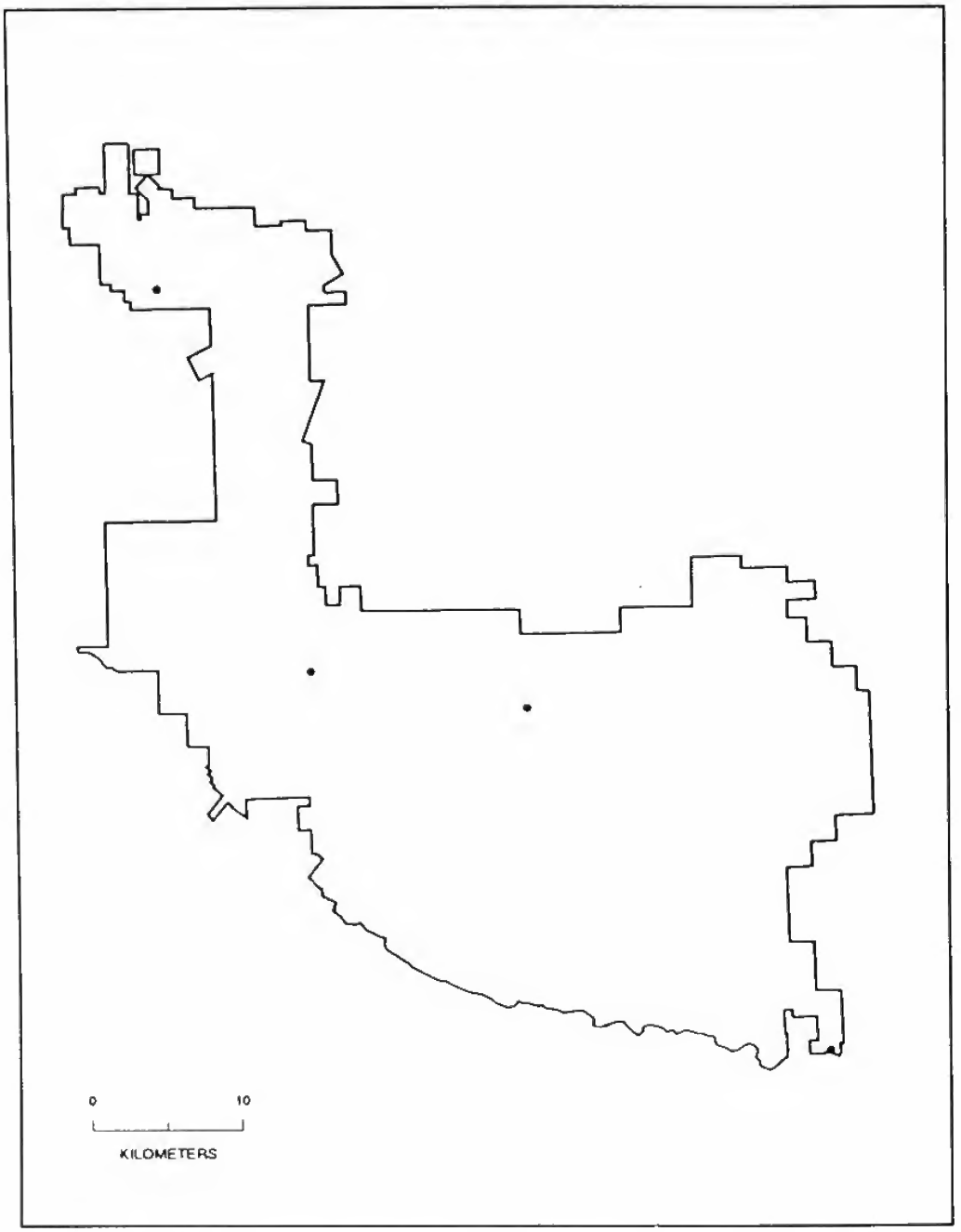

Figure 31. Localities of known specimens of *Cratogeomys castanops* from Big Bend Ranch State Park, Texas.

Cratogeomys is derived from the Greek "kratos," "gaia," and "mys," which translate to strength, land, and mouse, respectively. The specific epithet *castanops* is from the Greek "kastanea," and "ops," meaning chestnut, and face, respectively (Stangl et al., 1993).

Specimens Examined (4).— Presidio Co.: BBRSP, UTM coordinates: 13 587062E 3262884N, 1; BBRSP, UTM coordinates: 13 577321E 3287548N, 1; BBRSP, UTM coordinates: 13 601105E 3260471N, 1. Brewster Co.: BBRSP, UTM coordinates: 13 620726E 3238321N, 1.

Family Heteromyidae
(Pocket Mice and Kangaroo Rats)

Perognathus flavus (Baird, 1855)
Silky Pocket Mouse

Description.— *Perognathus flavus* is a small pocket mouse with blonde-buff dorsal pelage interspersed with black. The fur is soft and silky in texture. As in all members of this family, external fur-lined cheek pouches are present. The tail of this mouse is short and sparsely haired. A conspicuous pale buff patch is present just posterior to the small ears. The dental formula for *P. flavus* is: i 1/1, c 0/0, p 1/1, m 3/3, total 20.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 119.9 (66, 107-130, 4.5); length of tail vertebrae, 60.3 (66, 51-66, 2.9); length of hind foot, 16.5 (69, 15-18, 0.8); length of ear from notch, 6.2 (69, 5-7, 0.4); weight, 6.7 (65, 4.9-8.4, 0.8); greatest length of skull, 20.79 (20, 19.93-21.58, 0.43). No significant sexual dimorphism has been noted in this species, although males may have slightly longer tails (Best, 1993; Best and Skupski, 1994*a*).

P. flavus is distinguished easily from all other pocket mice at BBRSP by its small size, coloration, and silky fur.

Distribution.— *P. flavus* ranges from central Mexico, northward through the western two thirds of Texas and onto the Great Plains, and westward to western Utah and Arizona (Best and Skupski, 1994*a*; 1994*b*). In BBRSP, this pocket mouse is known from throughout the park (Fig. 32).

Natural History.— With a relative abundance index of 0.647, *P. flavus* was the fourth most abundant rodent at BBRSP. It accounted for 9.8 percent of all rodents trapped in the park. Schmidly (1977*a*) reported this pocket mouse as one of the most common small mammals in the Trans-Pecos, and this appears to be the situation at BBRSP.

P. flavus is a habitat generalist, and has been reported to occur in all the major habitat types found at BBRSP (Schmidly, 1977*a*; Best and Skupski, 1994*a*; 1994*b*). However, during this study, the silky pocket mouse was taken only in desert scrub and desert grassland habitats, neither to which it showed a significant preference (P=0.894). It is not known to have a preference for soil types (Best and Skupski, 1994*b*), and during this study, it was taken on all types of substrata encountered, including sand, sandy loam, gravel, rock, and boulder, but appeared to be more common on the latter three.

P. flavus may hibernate in some areas, but remains active during winter throughout much of its range (Best and Skupski, 1994*a*). During this study, silky pocket mice were taken only from April through November, despite extensive trapping during the winter months. These results suggest that the silky pocket mouse hibernates at BBRSP.

In the Trans-Pecos, the breeding season lasts from April to November, and females may bear multiple litters each year (Schmidly, 1977*a*). During this study, I examined 4 gravid females, three of which were carrying four embryos, and one that was carrying two embryos, and one lactating female with seven placental scars. Thus, the mean litter size was 4.2. Prior to this study, the largest litter known for this species was six (Best and Skupski, 1994*a*; 1994*b*). Pregnant females were examined on the following dates (number of embryos and corresponding crown-rump lengths in parentheses): 5 June (2 embryos, crown-rump length, 11), 2 August (4 embryos, crown-rump length, 9), 5 August (4 embryos, crown-rump length, 10), 11 October (4 embryos, crown-rump length, 2). Previously, no pregnant females had been recorded from the Trans-Pecos during August (Schmidly, 1977*a*). A lactating female was observed on 29 October. Testicular measurements of males ranged as follows: April, 5 X 3; May, 4 X 3 to 7 X 4; June, 4 X 2 to 6 X 4; July 4 X 3 to 5 X 4; August, 5 X 3; October, 3 X 2. Juveniles were observed among the population on 28 May and 3 July.

P. flavus is nocturnal, but occasionally may be active outside its burrow during the day. At night this

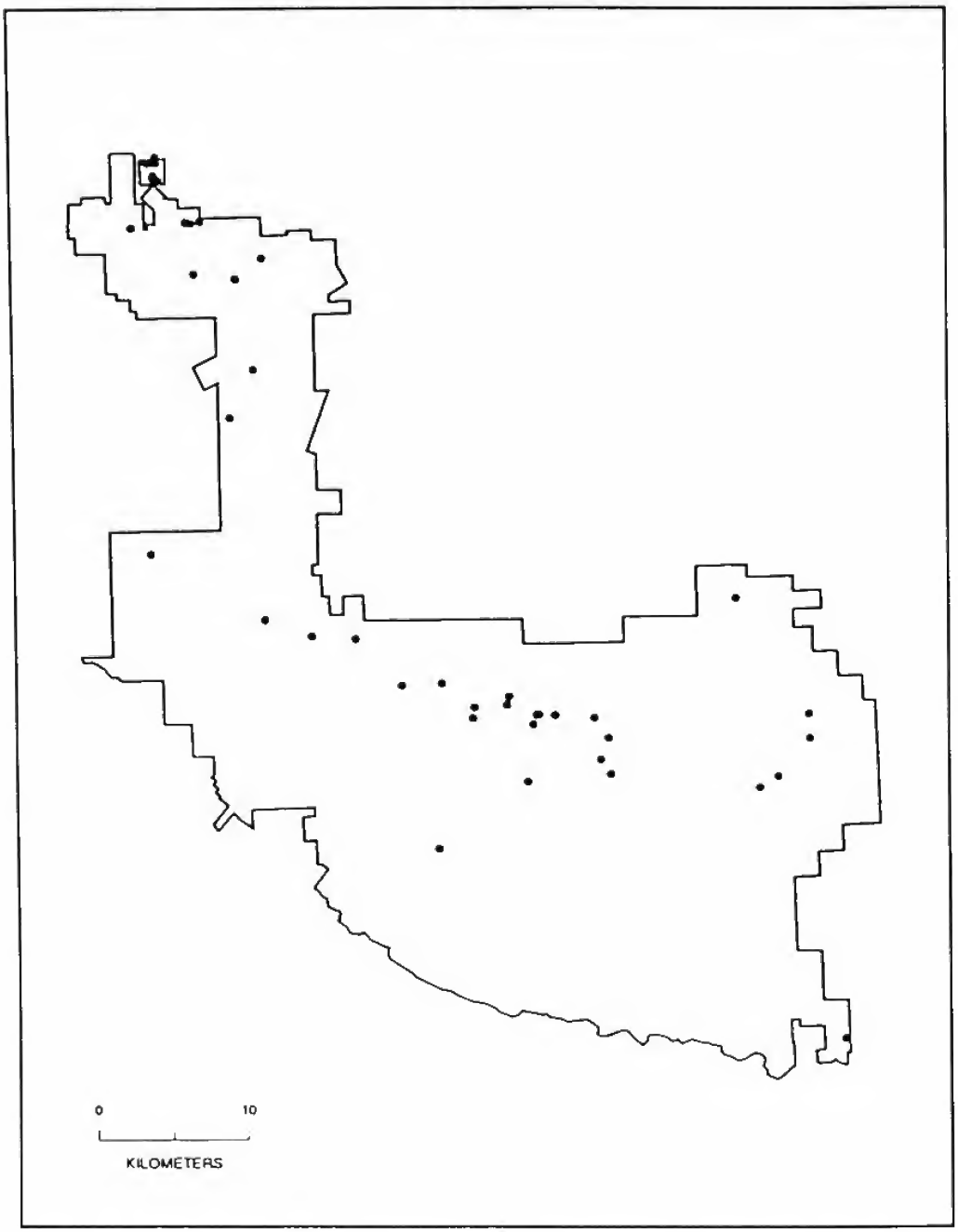

Figure 32. Localities of known specimens of *Perognathus flavus* from Big Bend Ranch State Park, Texas.

pocket mouse forages for seeds, which are collected and cached in its burrow for consumption the following day. In addition to seeds, *P. flavus* also will feed on green vegetation, juniper berries, and occasionally invertebrates (Best and Skupski, 1994*a*; 1994*b*).

Adult silky pocket mice were reported to undergo a single annual molt. Winter pelage reportedly is retained through spring and summer. Then, in late July or August, the worn winter pelage gradually is replaced by summer pelage. By September, the process is complete (Best and Skupski, 1994*a*; 1994*b*). This does not appear to be the situation at BBRSP, as adults undergoing seasonal molting were observed as early as 1 May,

and as late as 29 October. These data may indicate (1) early or late molt in some individuals, (2) a second annual molt, or (3) individuals molt at various times throughout the year.

Other rodents taken at the same localities as *P. flavus* at BBRSP included *Chaetodipus eremicus*, *C. hispidus*, *C. intermedius*, *C. nelsoni*, *Dipodomys merriami*, *Reithrodontomys megalotis*, *Peromyscus eremicus*, *P. leucopus*, *P. maniculatus*, *Onychomys arenicola*, and *Neotoma micropus*.

Mites were the only parasites found in association with silky pocket mice at BBRSP. Additional ectoparasites reported for this pocket mouse include ticks, lice, and fleas. Endoparasites known from *P. flavus* include protozoans and nematodes (Best and Skupski, 1994*a*; 1994*b*).

Comments.— The subspecies of *P. flavus* at BBRSP probably is *P. f. gilvus* Osgood, 1900. The generic name *Perognathus* is derived from the Greek "pera" and "gnathos," which translate to pouch and jaw, respectively. The specific epithet *flavus* is Latin for yellow (Stangl et al., 1993). Other workers (Lee and Engstrom, 1991) consider the taxon that Jones and Jones (1992) refer to as *P. flavus* to consist of two separate species, *P. flavus* and *P. merriami*. If the taxon regarded herein as *P. flavus* actually is two species, both probably occur in BBRSP (Davis and Schmidly, 1994). Continued investigation is required to resolve the systematic status of this taxon.

Specimens Examined (77).— Presidio Co.: BBRSP, UTM coordinates: 13 575323E 3292088N, 3; BBRSP, UTM coordinates: 13 576311E 3271128N, 1; BBRSP, UTM coordinates: 13 576390E 3296223N, 1; BBRSP, UTM coordinates: 13 576721E 3296287N, 1; BBRSP, UTM coordinates: 13 576773E 3295277N, 2; BBRSP, UTM coordinates: 13 576796E 3295418N, 1; BBRSP, UTM coordinates: 13 576836E 3296251N, 3; BBRSP, UTM coordinates: 13 576931E 3296613N, 2; BBRSP, UTM coordinates: 13 576970E 3296222N, 1; BBRSP, UTM coordinates: 13 576985E 3295102N, 1; BBRSP, UTM coordinates: 13 577120E 3295100N, 1; BBRSP, UTM coordinates: 13 578883E 3292424N, 2; BBRSP, UTM coordinates: 13 579237E 3292359N, 4; BBRSP, UTM coordinates: 13 579410E 3289121N, 1; BBRSP, UTM coordinates: 13 579859E 3292474N, 2; BBRSP, UTM coordinates: 13 581659E 3279903N, 1; BBRSP, UTM coordinates: 13 582110E 3288790N, 1; BBRSP, UTM coordinates: 13 583205E 3282984N, 2; BBRSP, UTM coordinates: 13 583788E 3266885N, 2; BBRSP, UTM coordinates: 13 583846E 3290112N, 3; BBRSP, UTM coordinates: 13 586886E 3265832N, 1; BBRSP, UTM coordinates: 13 589824E 3265632N, 3; BBRSP, UTM coordinates: 13 592858E 3262597N, 1; BBRSP, UTM coordinates: 13 595478E 3262749N, 1; BBRSP, UTM coordinates: 13 597424E 3260494N, 1; BBRSP, UTM coordinates: 13 597543E 3261182N, 2; BBRSP, UTM coordinates: 13 599607E 3261323N, 2; BBRSP, UTM coordinates: 13 599751E 3261864N, 1; BBRSP, UTM coordinates: 13 600868E 3256344N, 3; BBRSP, UTM coordinates: 13 601273E 3260059N, 3; BBRSP, UTM coordinates: 13 601508E 3260673N, 1; BBRSP, UTM coordinates: 13 601622E 3260685N, 1; BBRSP, UTM coordinates: 13 602666E 3260640N, 1; BBRSP, UTM coordinates: 13 605201E 3260431N, 1; BBRSP, UTM coordinates: 13 605576E 3257735N, 2; BBRSP, UTM coordinates: 13 606085E 3259112N, 1; BBRSP, UTM coordinates: 13 606207E 3256765N, 3; BBRSP, UTM coordinates: 13 614350E 3268071N, 4; BBRSP, UTM coordinates: 13 615747E 3255837N, 1; BBRSP, UTM coordinates: 13 616984E 3256548N, 1; BBRSP, UTM coordinates: 13 619125E 3258986N, 3; BBRSP, Rancherias Springs, 1 (SRSU). Brewster Co.: BBRSP, UTM coordinates: 13 619081E 3260561N, 2; BBRSP, UTM coordinates: 13 621243E 3239655N, 2.

Chaetodipus eremicus (Mearns, 1898)
Chihuahuan Desert Pocket Mouse

Description.— *Chaetodipus eremicus* is a medium-sized pocket mouse with a buff to pale brown dorsal pelage. Varying degrees of black may be sprinkled about the dorsal pelage presenting an overall grayish-brown color. The pelage is coarse and lacks rump spines. The tail is long and tufted, the ears are short, and the soles of the hind feet are pale-fleshy in color. The dental formula for *C. eremicus* is: i 1/1, c 0/0, p 1/1, m 3/3, total 20.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 174.6 (82, 153-192, 7.7); length of tail vertebrae, 95.7 (82, 86-112, 4.7); length of hind foot, 22.5 (90, 20-24, 1.0); length of ear from notch, 7.8 (90, 7-9, 0.5); weight, 14.6 (79, 9-20, 2.6); greatest length of skull, 25.57 (20, 24.78-26.40, 0.44). No sexual dimorphism is apparent in this species (Manning et al., 1996).

C. eremicus can be confused with two other species of *Chaetodipus* that occur at BBRSP. It is fairly easy to differentiate *C. eremicus* from *C. nelsoni*. The former usually is paler in color, lacks rump spines, and has pale colored soles on the hind feet. In contrast, the latter is darker, has prominent rump spines, and has dark soles on the hind feet. These two species of pocket mice also can be separated consistently based on cranial morphology as described by Manning et al. (1996). Differentiation between *C. eremicus* and *C. intermedius* poses more of a problem, as the appearance of the dorsal pelage of these two mice is similar. However, upon close examination, weak rump spines can be noticed on *C. intermedius*, whereas they are completely absent from *C. eremicus*. Cranial morphology also can be used to assist in differentiating these two species. *C. eremicus* has been shown to have a significantly larger greatest length of skull than *C. intermedius* (Wilkins and Schmidly, 1979). This observation appears to hold true for specimens from BBRSP as can be noted in the list of measurements in the respective accounts of these two species. Furthermore, the interparietal of *C. eremicus* is not in contact with the mastoid bullae, being separated by narrow projections of the parietals and supraoccipitals. In contrast, the interparietal of *C. intermedius* is in contact, or nearly so, with the mastoid bullae (Davis and Schmidly, 1994). At BBRSP, the three species of *Chaetodipus* treated above were distinguished easily based on karyology. *C. eremicus* had 2N=46 and FN=56, *C. intermedius* had 2N=46 and FN=58, and *C. nelsoni* had 2N=48 and FN=58. The karyotypes for *C. eremicus* and *C. nelsoni* were consistent with those reported by Lee et al. (1991), and the karyotype for *C. nelsoni* was consistent with that reported by Patton (1970).

Distribution.— *Chaetodipus eremicus* ranges from north-central Mexico, northward to southwestern Texas and southern New Mexico (Lee et al., 1996). In BBRSP, this pocket mouse was recorded throughout the park (Fig. 33).

Natural History.— With a relative abundance index of 1.294, *C. eremicus* was the most frequently encountered rodent at BBRSP. It accounted for 19.5 percent of all rodents trapped. Trapping results indicate that this pocket mouse is both widespread and abundant in BBRSP.

C. eremicus has been reported to prefer desert scrub habitat (Schmidly, 1977*a*). During this study, *C. eremicus* was taken in desert scrubland, but also in desert grassland, and riparian habitats. However, this pocket mouse showed a significant preference for desert scrub over the latter two habitats ($P<0.001$). There was no preference shown between grassland and riparian habitats ($P=0.52$). The majority of the specimens taken in riparian areas were acquired from along the Rio Grande. In addition to desert scrub vegetation, *C. eremicus* reportedly favors sandy or silty soils, and is absent from areas with gravelly or rocky substrata (Davis and Schmidly, 1994). During this study, this pocket mouse was, in fact, taken most commonly on sandy or silty soils (81 percent), but some were acquired on gravelly, rocky, or bouldery substrata (19 percent). Because *C. eremicus* has been considered a sand dweller, whereas its similar appearing congeners, *C. intermedius* and *C. nelsoni*, have been regarded as rock dwellers (Davis and Schmidly, 1994), the substrate quality from which specimens were collected often was considered in the identification process. However, considering that 19 percent of *C. eremicus* taken during this study were from gravelly or rocky areas, this practice should be regarded as unreliable.

C. eremicus is known to be less active during the winter months, and may enter a period of torpor during extremely cold weather (Schmidly, 1977*a*). During this study, this pocket mouse was encountered from March to December. In nearby Big Bend National Park, Manning et al. (1996) found *C. eremicus* to be active only during these months as well.

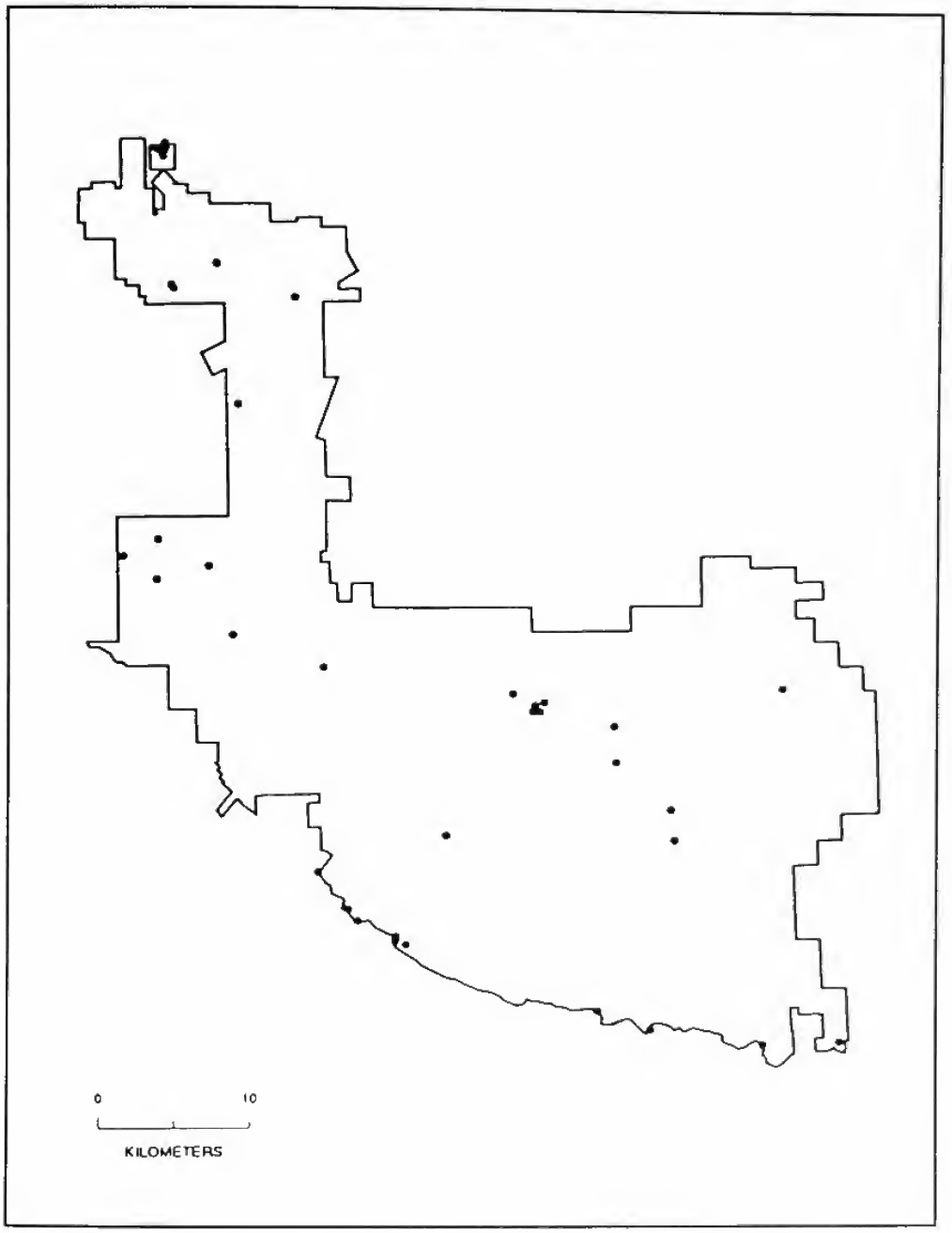

Figure 33. Localities of known specimens of *Chaetodipus eremicus* from Big Bend Ranch State Park, Texas.

Apparently two annual periods of peak reproductive activity occur in *C. eremicus*, one in the spring and the other in late summer (Schmidly, 1977*a*). However, pregnant females are known from most months that this pocket mouse is active (Manning et al., 1996). Schmidly (1977*a*) reported a mean litter size of 3.6, with a range of two to five. However, Manning et al. (1996) reported examining a female with 15 placental scars, suggesting a much greater range in litter size. During this study, I examined 11 gravid females taken between 4 and 27 July. The number of embryos ranged from three to five, with a mean of 3.8. Pregnant females (with number of embryos and corresponding crown-rump lengths in parentheses) were examined on the following dates: 4 May (3 embryos, crown-rump length, 2; 3 embryos, crown-rump length, 3; 4 embryos, crown-rump

length, 3), 14 May (1 embryo, crown-rump length, 4), 3 May (2 embryos, crown-rump length, 8), 13 May (2 embryos, crown-rump length, 10), 14 May (3 embryos, crown-rump length, 5; 4 embryos, crown-rump length, 3), 26 May (5 embryos, crown-rump length, 18), 3 June (4 embryos, crown-rump length, 15), 21 June (4 embryos, crown-rump length, 5; 4 embryos, crown-rump length, 7), 27 July (5 embryos, crown-rump length, 6). Lactating females were noted on 5 and 27 July, 13 September, and 8 and 10 December. Juveniles were observed in the population on 14 May, 5, 12, and 27 July, 22 August, 29 September, and 4 and 8 October. Subadults were noted on 11 June, 5 and 13 July, 22 August, 17 and 29 October, 4 November, and 8 December. Testicular measurements of adult males ranged as follows: March, 6 X 4; April, 7 X 4 to 10 X 4; May, 6 X 3 to 15 X 5; June, 7 X 4 to 12 X 6; July, 10 X 4; September, 4 X 2 to 9 X 4; October, 3 X 1 to 7 X 4; November, 3 X 2 to 5 X 2; December, 3 X 1 to 5 X 3.

C. eremicus is nocturnal and forages primarily for seeds, especially those of mesquite, creosote-bush, and broomweed (Schmidly, 1977*a*).

Seasonal molting in *C. eremicus* previously has been documented as occurring from June through October (Manning et al., 1996). During this study, molting adults were taken during May, June, July, September, November, and December. It is not known if these observations are due to a single annual molt that occurs at various times throughout the year, or two seasonal molts, one during spring, and the other during fall.

Other rodents taken at the same localities as *C. eremicus* at BBRSP included *Thomomys bottae*, *Spermophilus spilosoma*, *Perognathus flavus*, *Chaetodipus hispidus*, *C. intermedius*, *C. nelsoni*, *Dipodomys merriami*, *Reithrodontomys fulvescens*, *R. megalotis*, *Peromyscus eremicus*, *P. leucopus*, *P. maniculatus*, *P. pectoralis*, and *Neotoma micropus*. The sympatric occurrence of *C. eremicus*, *C. intermedius*, and *C. nelsoni* is an interesting situation. Reportedly, *C. eremicus* is segregated from *C. intermedius* and *C. nelsoni* ecologically, with the former species restricted to sandy or silty substrata, and the latter two species limited to rocky or gravelly substrata (Schmidly, 1977*a*). The two rock-dwelling species, *C. intermedius* and *C. nelsoni*, reportedly are separated geographically, with the former occurring in the western Trans-Pecos, and the latter occurring to the east. Previously, there were only two localities from which these two pocket mice were taken together (Wilkins and Schmidly, 1979). Interestingly, *C. eremicus* and *C. nelsoni* were taken sympatrically and syntopically on several occasions. Moreover, at one locality, all three species of these pocket mice were taken. This is the first account of *C. eremicus*, *C. intermedius*, and *C. nelsoni* occurring at the same locality. This site, which is at the west end of the park, is in creosote scrub habitat with a rocky, gravelly substrate. The ecologic and biogeographic relations of these pocket mice are deserving of further investigation.

Various mites, especially on the tail, were observed on specimens of *C. eremicus* from BBRSP. In addition to mites, other ectoparasites previously reported from desert pocket mice include lice and fleas. Endoparasites known to infect desert pocket mice include protozoans and nematodes. *C. eremicus* is known to harbor the pathogenic fungus *Coccidioides immitis*, the etiologic agent of valley fever (Whittaker et al., 1993).

Comments.— *Chaetodipus eremicus* is a monotypic species. The generic name *Chaetodipus* is derived from the modern Latin "chaeta" and the Greek "dis" and "pous," which translate to bristle, twice, and foot, respectively. The specific epithet *eremicus* is from the Greek "eremikos," meaning solitary (Stangl et al., 1993). Previously, *C. eremicus* was regarded as a subspecies of *C. penicillatus* until recent work based on mitochondrial DNA sequence data indicated that *eremicus* was worthy of specific status (Lee et al., 1996).

Specimens Examined (114).— Presidio Co.: BBRSP UTM coordinates: 13 573986E 3270053N, 2; BBRSP UTM coordinates: 13 576206E 3268568N, 1; BBRSP UTM coordinates: 13 576311E 3271128N, 1; BBRSP UTM coordinates: 13 576390E 3296223N, 2; BBRSP UTM coordinates: 13 576646E 3296118N, 1; BBRSP UTM coordinates: 13 576699E 3296276N, 2; BBRSP UTM coordinates: 13 576721E 3296287N, 4; BBRSP UTM coordinates: 13 576757E 3296109N, 4; BBRSP UTM coordinates: 13 576808E 3295784N, 1;

BBRSP UTM coordinates: 13 576836E 3296251N, 9; BBRSP UTM coordinates: 13 576842E 3296279N, 2; BBRSP UTM coordinates: 13 576846E 3296245N, 5; BBRSP UTM coordinates: 13 576931E 3296613N, 2; BBRSP UTM coordinates: 13 576970E 3296222N, 2; BBRSP UTM coordinates: 13 577002E 3296360N, 1; BBRSP UTM coordinates: 13 577321E 3287548N, 1; BBRSP UTM coordinates: 13 577472E 3287353N, 1; BBRSP UTM coordinates: 13 579684E 3269447N, 14; BBRSP UTM coordinates: 13 580342E 3288931N, 1; BBRSP UTM coordinates: 13 581230E 3264998N, 4; BBRSP UTM coordinates: 13 581659E 3279903N, 1; BBRSP UTM coordinates: 13 585434E 3286791N, 1; BBRSP UTM coordinates: 13 586777E 3249651N, 5; BBRSP UTM coordinates: 13 587184E 3262927N, 1; BBRSP UTM coordinates: 13 588746E 3247263N, 3; BBRSP UTM coordinates: 13 589348E 3246503N, 9; BBRSP UTM coordinates: 13 591851E 3245491N, 3; BBRSP UTM coordinates: 13 592496E 3244969N, 1; BBRSP UTM coordinates: 13 599495E 3261227N, 1; BBRSP UTM coordinates: 13 600786E 3260060N, 8; BBRSP UTM coordinates: 13 600914E 3260458N, 1; BBRSP UTM coordinates: 13 601273E 3260059N, 3; BBRSP UTM coordinates: 13 601508E 3260673N, 2; BBRSP UTM coordinates: 13 604886E 3240689N, 1; BBRSP UTM coordinates: 13 606085E 3259112N, 1; BBRSP UTM coordinates: 13 606207E 3256765N, 1; BBRSP UTM coordinates: 13 608309E 3239482N, 3; BBRSP UTM coordinates: 13 609770E 3253645N, 1; BBRSP UTM coordinates: 13 615800E 3238476N, 3; BBRSP, Colorado Canyon, 1 (SRSU); BBRSP, Rancherias Springs, 1 (SRSU); BBRSP, Smith Ranch, Fresno Canyon, 1 (SRSU). Brewster Co.: BBRSP UTM coordinates: 13 617281E 3261484N, 1; BBRSP UTM coordinates: 13 620927E 3238664N, 1.

Chaetodipus hispidus (Baird, 1858)
Hispid Pocket Mouse

Description.— *Chaetodipus hispidus* is a large pocket mouse with a coarse dorsal pelage that is buffy-blonde mixed with black above, and with clear buff on the sides. The tail is relatively short (less than half the total length), bicolored, scantly haired, and lacks a terminal tuft. The dental formula for *C. hispidus* is: i 1/1, c 0/0, p 1/1, m 3/3, total 20.

Means of external and cranial measurements (with extremes in parentheses) of three adult specimens from BBRSP are: total length, 208.0 (196-215); length of tail vertebrae, 95.7 (85-104); length of hind foot, 24.0 (23-25); length of ear from notch, 12.0 (11-13); weight, 37.3 (33-46); greatest length of skull, 30.62 (29.78-31.17). No sexual dimorphism is evident in *C. hispidus* (Best, 1993).

The large size of *C. hispidus*, coupled with its relatively short, untufted tail, distinguishes this species from the other heteromyids at BBRSP.

Distribution.— *C. hispidus* ranges from central Mexico, northward through the central United States, to North Dakota (Paulson, 1988). In BBRSP, this pocket mouse is known only from a single locality in the Cienega area (Fig. 34).

Natural History.— Three hispid pocket mice were taken during this study, which resulted in a relative abundance index of 0.024. This species accounted for 0.4 percent of rodents trapped. Schmidly (1977*a*:84) considered *C. hispidus* as "one of the rarest pocket mice in the Trans-Pecos," and apparently this is the situation at BBRSP. Prior to this report, this species was known from Presidio County only on the basis of four specimens taken in the 19th century.

C. hispidus reportedly prefers dry, grassland habitats with sandy or friable soils (Schmidly, 1977*a*; Paulson, 1988). The site at which this pocket mouse was taken at BBRSP was overgrazed grassland with scattered mesquite, false willow, and desert willow. The soil was a hard, fine loam with patches of sand and gravel.

During this study, *C. hispidus* was taken during April and July. This species is not known to hibernate, but may become torpid during periods of food shortage (Paulson, 1988).

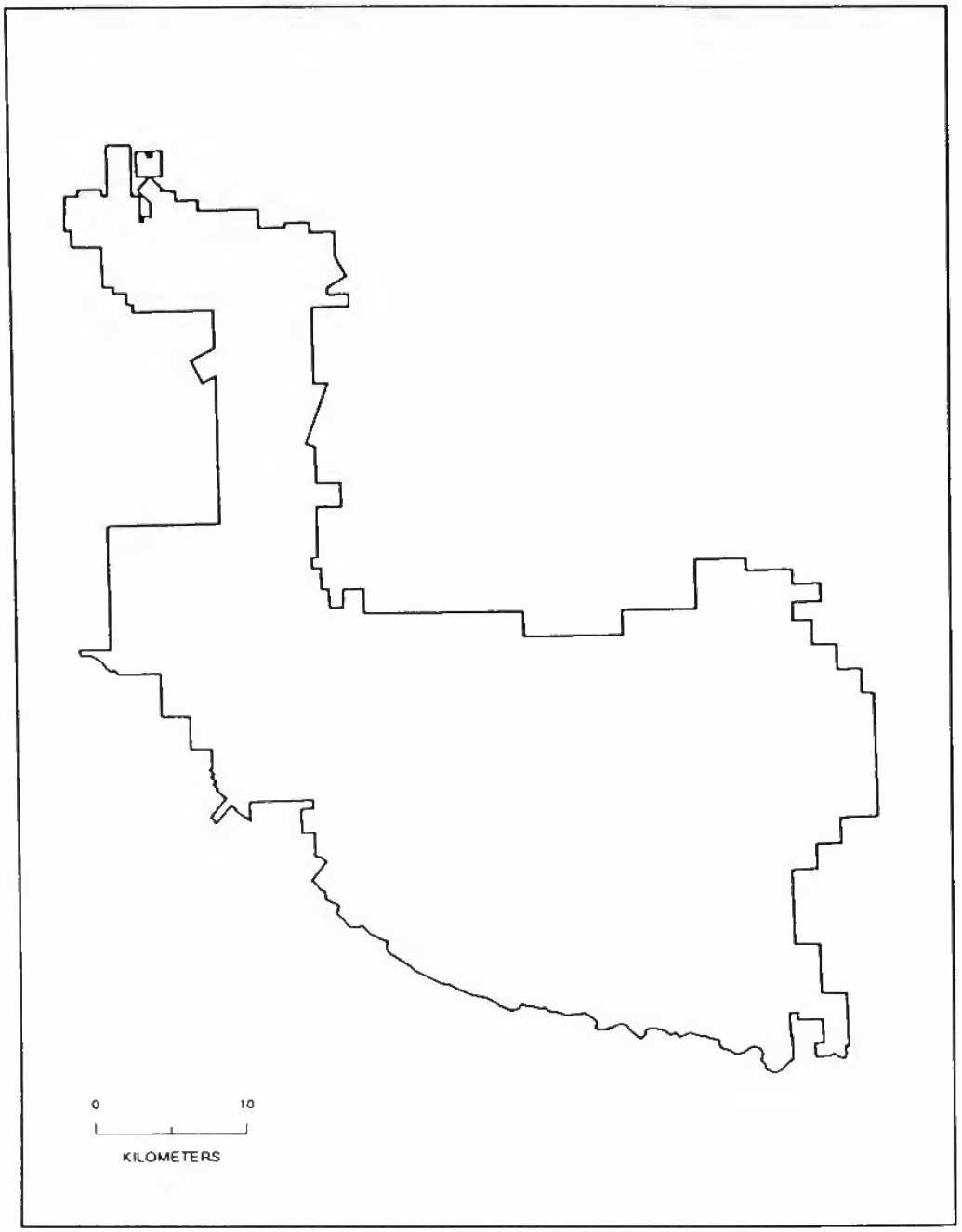

Figure 34. Localities of known specimens of *Chaetodipus hispidus* from Big Bend Ranch State Park, Texas.

Little is known about the reproductive habits of *C. hispidus* in the Big Bend area. The breeding period of this mouse is nearly year round in south Texas (Davis and Schmidly, 1994), and that probably is the situation at BBRSP. A male taken on 5 July appeared to be in reproductive condition (testes, 18 X 5). Litter sizes typically range from two to nine, with a mean of six (Davis and Schmidly, 1994). Females may bear two or more litters annually (Jones et al., 1983).

C. hispidus is active at night, during which time it forages primarily for seeds, especially those of mesquite, cactus, and sagebrush. Seeds most often are collected from the ground (Reichman and Price, 1993),

but occasionally this pocket mouse will climb vegetation in an effort to gather food (Lemen and Freeman, 1995). Seeds gathered and stored during the warmer months allow individuals to subsist through winter. In addition to seeds, some green vegetation and insects may be consumed (Jones et al., 1983).

Other rodents taken at the same locality as *C. hispidus* at BBRSP included *Perognathus flavus*, *Chaetodipus eremicus*, *Dipodomys merriami*, *Reithrodontomys megalotis*, *Peromyscus eremicus*, *P. leucopus*, and *P. maniculatus*. In addition, two lagomorphs, *Sylvilagus audubonii* and *Lepus californicus*, frequently were observed grazing at the site where *C. hispidus* was taken. Davis and Schmidly (1994) reported that *C. hispidus* usually avoids areas of dense grass, and it is conceivable that the extensive grazing activity by lagomorphs at this site is maintaining suitable habitat for this pocket mouse.

No parasites were observed in association with hispid pocket mice from BBRSP. Ectoparasites previously documented to infest *C. hispidus* include mites, ticks, lice, and fleas (Turner, 1974; Paulson, 1988; Whitaker et al., 1993). Endoparasites reported to infect *C. hispidus* include protozoans. The hispid pocket mouse has been implicated as a reservoir for *Trypanosoma cruzi*, the etiologic agent of Chaga disease. In the lower Rio Grande Valley of Texas, 16 percent of hispid pocket mice examined tested positive for this protozoan (Burkholder et al., 1980). *C. hispidus* also has been known to carry *Borrelia*-like spirochetes (Eads and Hightower, 1952). In addition, *C. hispidus* is known to harbor the flea *Thrassis fotus*, a vector of sylvatic plague (Rail et al., 1969).

Comments.— The subspecies of *C. hispidus* that occurs at BBRSP is *C. h. paradoxus* (Merriam, 1889). See the account on *Chaetodipus eremicus* for the etymology of the generic name. The specific epithet *hispidus* is Latin for shaggy (Stangl et al., 1993).

Specimens Examined (3).— Presidio Co.: BBRSP, UTM coordinates: 13 576836E 3296251N, 3.

Chaetodipus intermedius Merriam, 1889
Rock Pocket Mouse

Description.— *Chaetodipus intermedius* is a medium-sized pocket mouse with a buffy-brown dorsal pelage sprinkled with black. The pelage is rather coarse, with weak, sometimes inconspicuous spines on the rump. The tail is long and tufted, the ears are short, and the soles of the hind feet are pale in color. The dental formula for *C. intermedius* is: i 1/1, c 0/0, p 1/1, m 3/3, total 20.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 172.9 (12, 164-185, 6.7); length of tail vertebrae, 97.1 (12, 86-107, 5.5); length of hind foot, 21.2 (13, 20-22.5, 0.6); length of ear from notch, 7.9 (13, 7-8, 0.3); weight, 12.8 (13, 11-14, 1.1); greatest length of skull, 23.88 (13, 22.83-24.53, 0.48). Males may average slightly larger than females (Best, 1993).

C. intermedius is confused easily with *C. eremicus*, but the two can be distinguished as described in the account of the latter. *C. intermedius* may also be mistaken for *C. nelsoni*, which frequently occupies the same habitat as *C. intermedius*. These two pocket mice usually can be separated on the basis of pelage appearance. *C. intermedius* is pale brown washed with black, and has weak rump spines. In contrast, *C. nelsoni* usually is darker, almost black in color, and possesses heavy, black-tipped rump spines. However, coloration of *C. nelsoni* is variable, and pale-colored individuals are known from BBRSP. Additional characters that can be used to separate these two pocket mice include dark foot pads and the presence of a small, white patch at the base of the ear in *C. nelsoni*, versus paler foot pads and no white patch at the base of the ears in *C. intermedius*. These two pocket mice can be distinguished easily by karyotypes as described in the account on *C. eremicus*.

Distribution.— *C. intermedius* ranges from northwestern Mexico, north and north-westward through Trans-Pecos Texas and the southern part of the southwestern United States (Schmidly et al., 1993). In BBRSP, *C. intermedius* is known only from the west-

ern fourth of the park (Fig. 35). Davis and Schmidly (1994) report this pocket mouse as occurring throughout most of the Trans-Pecos, as well as from one county east of the Pecos River. Thus, the eastern limits of the range of this species were defined by specimens from Winkler, Reeves, and Brewster counties (Davis and Schmidly, 1994). However, specimens from these localities apparently were misidentified; the record from Brewster County actually being *C. nelsoni* (Wilkins and Schmidly, 1979), and those from Winkler and Reeves counties being *P. eremicus* (Jones and Manning, 1991). This resulted in the eastern limit of the range of *C. intermedius* being redefined by a record from 5 mi. E, 2 mi. S Presidio, Presidio County (Wilkins and Schmidly, 1979). The easternmost site from which *C. intermedius* was taken at BBRSP during this study is approximately 15 km east of this locality, and thus, redefines the eastern limit of the range of *C. intermedius*.

Natural History.— During this study, *C. intermedius* was found to have a relative abundance index of 0.105. This pocket mouse accounted for 1.6 percent of all rodents trapped. These figures indicate that *C. intermedius* is uncommon at BBRSP. This probably is do to the fact that the park is situated on the eastern boundary of this species' distribution, rather than lack of suitable habitat.

C. intermedius prefers desert scrub habitat dominated by creosote-bush (Schmidly, 1977*a*), and this was the only type of habitat from which this mouse was taken at BBRSP. It reportedly favors areas of boulders and rocks, but also is known to occur on gravelly substrata (Davis and Schmidly, 1994). All specimens acquired during this study were taken from the latter.

During this study, *C. intermedius* was taken during March, May, and June.There is no documentation of this pocket mouse entering seasonal dormancy (French, 1993), and probably is active year round at BBRSP.

C. intermedius apparently begins breeding in February or March, and continues to do so for several months. Pregnant females, which carry three to six young, are known from May, June, and July. Juvenile individuals have been observed during April, May, June, and August (Davis and Schmidly, 1994). Adult males examined during this study had testicular measurements as follows: 18 March, 12 X 6; 2 May, 6 X 4 and 7 X 4; 21 June, 7 X 4; 22 June, 7 X 4.

The rock pocket mouse is strictly nocturnal, at which time it forages primarily for the seeds of herbaceous plants (Davis and Schmidly, 1994). Seeds are cached for consumption during periods of environmental stress. In addition, caching may help this pocket mouse maintain a diverse diet, and the growth of fungi on cached seeds may increase their nutritional value (Reichman and Price, 1993).

Little is known about annual molting in *C. intermedius*. Adult specimens undergoing seasonal molting at BBRSP were observed on 21 and 22 June.

Other species of rodents taken at the same localities as *C. intermedius* at BBRSP included *Perognathus flavus*, *Chaetodipus eremicus*, *C. nelsoni*, *Dipodomys merriami*, and *Peromyscus eremicus*. See the account on *C. eremicus* for a discussion on the sympatry of *C. eremicus*, *C. intermedius*, and *C. nelsoni*.

Mites noted on the tail were the only parasites observed in association with specimens of *C. intermedius* from BBRSP. Ectoparasites previously reported from *C. intermedius* are restricted to several species of mites. Endoparasites known from *C. intermedius* include protozoans and nematodes. The pathogenic fungus *Coccidioides immitis* is known to infect *C. intermedius* (Whitaker et al., 1993).

Comments.— The subspecies of *C. intermedius* that occurs at BBRSP is *C. i. intermedius* (Merriam, 1889). See the account on *Chaetodipus eremicus* for the etymology of the generic name. The specific epithet *intermedius* is Latin for intermediate (Stangl et al., 1993).

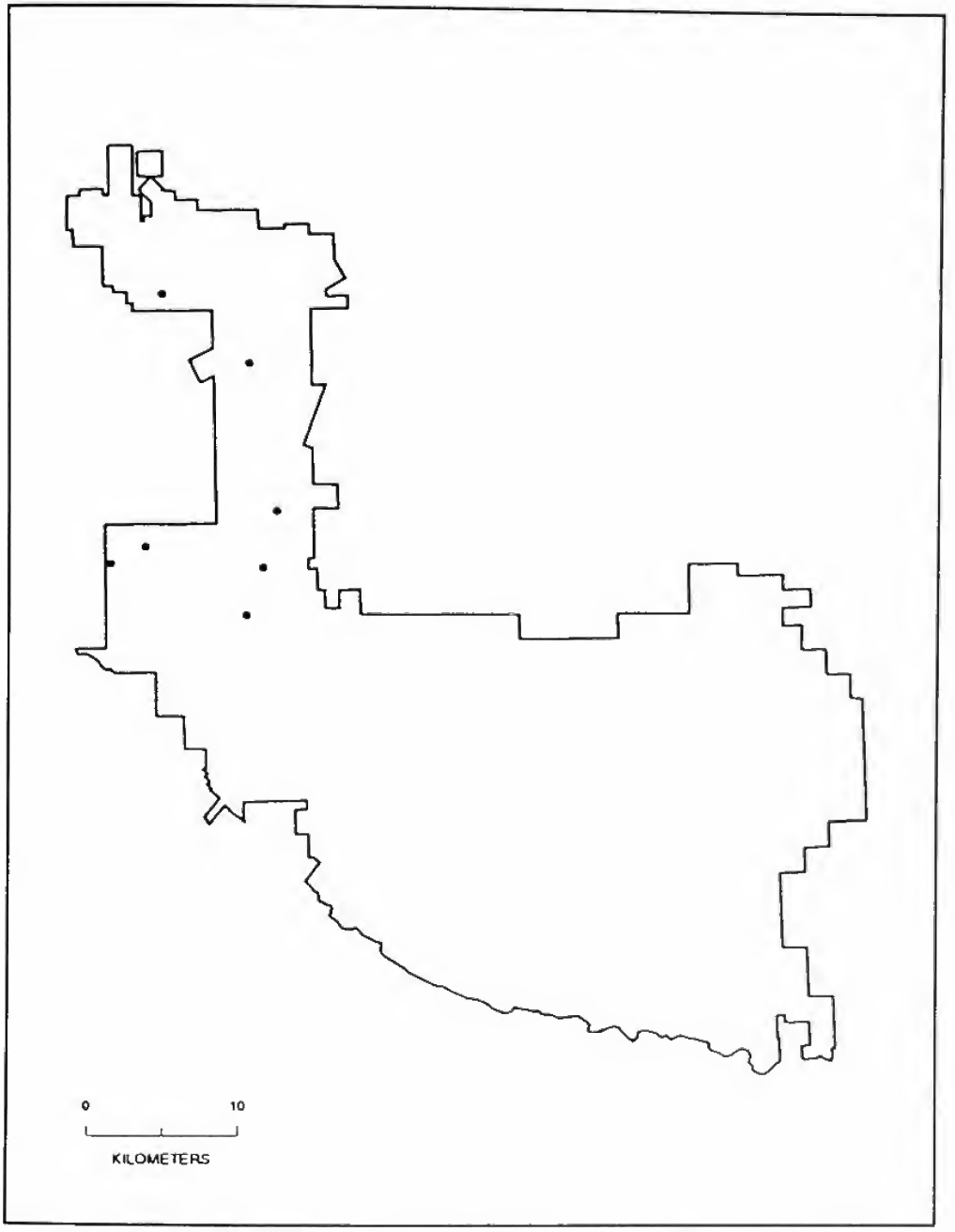

Figure 35. Localities of known specimens of *Chaetodipus intermedius* from Big Bend Ranch State Park, Texas.

Specimens Examined (13).— Presidio Co.: BBRSP, UTM coordinates: 13 573986E 3270053N, 2; BBRSP, UTM coordinates: 13 576311E 3271128N, 1; BBRSP, UTM coordinates: 13 577526E 3287386N, 1; BBRSP, UTM coordinates: 13 582906E 3266716N, 3; BBRSP, UTM coordinates: 13 583205E 3282984N, 2; BBRSP, UTM coordinates: 13 584021E 3269813N, 1; BBRSP, UTM coordinates: 13 584964E 3273523N, 3.

Chaetodipus nelsoni Merriam, 1894
Nelson's Pocket Mouse

Description.— *Chaetodipus nelsoni* is a medium-sized pocket mouse with grayish buff dorsal pelage that is washed heavily with black. The pelage is coarse with numerous, often back-tipped spines present on the rump. The tail is long and tufted, and the ears are short with a small white patch at the base. The soles of the hind feet are dark in color. The dental formula for *C. nelsoni* is: i 1/1, c 0/0, p 1/1, m 3/3, total 20.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 183.9 (47, 164-196, 6.5); length of tail vertebrae, 103.5 (47, 90-110, 4.2); length of hind foot, 21.8 (59, 20-24, 0.8); length of ear from notch, 8.2 (59, 6-9, 0.5); weight, 14.6 (56, 10-19, 1.8); greatest length of skull, 25.18 (20, 23.22-26.20, 0.66). No significant sexual dimorphism is apparent in this pocket mouse (Manning et al., 1996).

C. nelsoni can be mistaken for *C. eremicus* and *C. intermedius*. See the accounts of these two species for distinguishing characters.

Distribution.— *C. nelsoni* ranges from north-central Mexico northward to southwestern Texas and southeastern New Mexico (Best, 1994). In BBRSP, it is known from scattered localities throughout most of the park (Fig. 36).

Natural History.— During this study, *C. nelsoni* was found to have a relative abundance index of 0.615. It accounted for 9.3 percent of all rodents trapped, making it the fifth most abundant rodent in the park. Best (1994) reported that Nelson's pocket mouse is among the most common pocket mice throughout its range, and this appears to be the situation at BBRSP.

Schmidly (1977*a*) reported that in the Trans-Pecos in general, this pocket mouse has a strong preference for desert scrub and grassland vegetation. At BBRSP, *C. nelsoni* was taken in these two habitats, as well as in riparian and juniper roughland habitats. Trap success indicated that this pocket mouse does, in fact, prefer both desert scrub, and grassland over riparian habitat ($P<0.001$ and $P=0.001$, respectively). Capture rates were higher in both desert scrub and grassland than in juniper roughland, but the latter habitat was sparse, and therefore lacked adequate sampling for statistical comparisons. There was no significant difference between capture rates in desert scrub and desert grassland ($P=0.204$). In addition to scrub and grassland vegetation, *C. nelsoni* also is known to have a preference for rocky substrata, although it also may occur in sandy areas (Best, 1994). During this study, it most frequently was taken in rocky or gravelly situations (87 percent), but occasionally was taken on sandy substrata (13 percent). However, in all but one of the occasions where *C. nelsoni* was taken associated with sand, there were rocks scattered about the sand. Therefore, 99 percent of *C. nelsoni* specimens collected during this study were taken from substrata that were at least partially associated with rocks.

C. nelsoni does not hibernate and reportedly is active year round (Best, 1994). This appears to be the situation at BBRSP, as specimens were taken during each month, excluding January and April.

The breeding season of Nelson's pocket mouse reportedly commences in February and continues through July (Schmidly, 1977*a*). Females are known to give birth to two to five (mean, 3.2) young per litter (Schmidly, 1977*a*; Best, 1994). At BBRSP, I examined three gravid females carrying two to three (mean, 2.7) embryos. They were taken on 27 May (3 embryos, crown-rump length, 22), 30 May (3 embryos, crown-rump length, 8), and 3 June (2 embryos, crown-rump length, 15). Lactating females were noted on 22 June and 24 July. Juveniles were observed in the population on 30 and 31 May, 3 and 25 June, 3 July, and 22 August. Subadults were taken on 2, 3, and 26 July, and 4 September. Testicular measurements of adult males ranged as follows: February, 8 X 4; March, 8 X 4; May, 4 X 8 to 10 X 5; June, 7 X 4 to 8 X 4; July, 7 X 3 to 9 X 4; August, 7 X 3 to 8 X 4; October, 5 X 2; November, 4 X 2; December, 5 X 3. The above reproductive data are consistent with the reproductive period

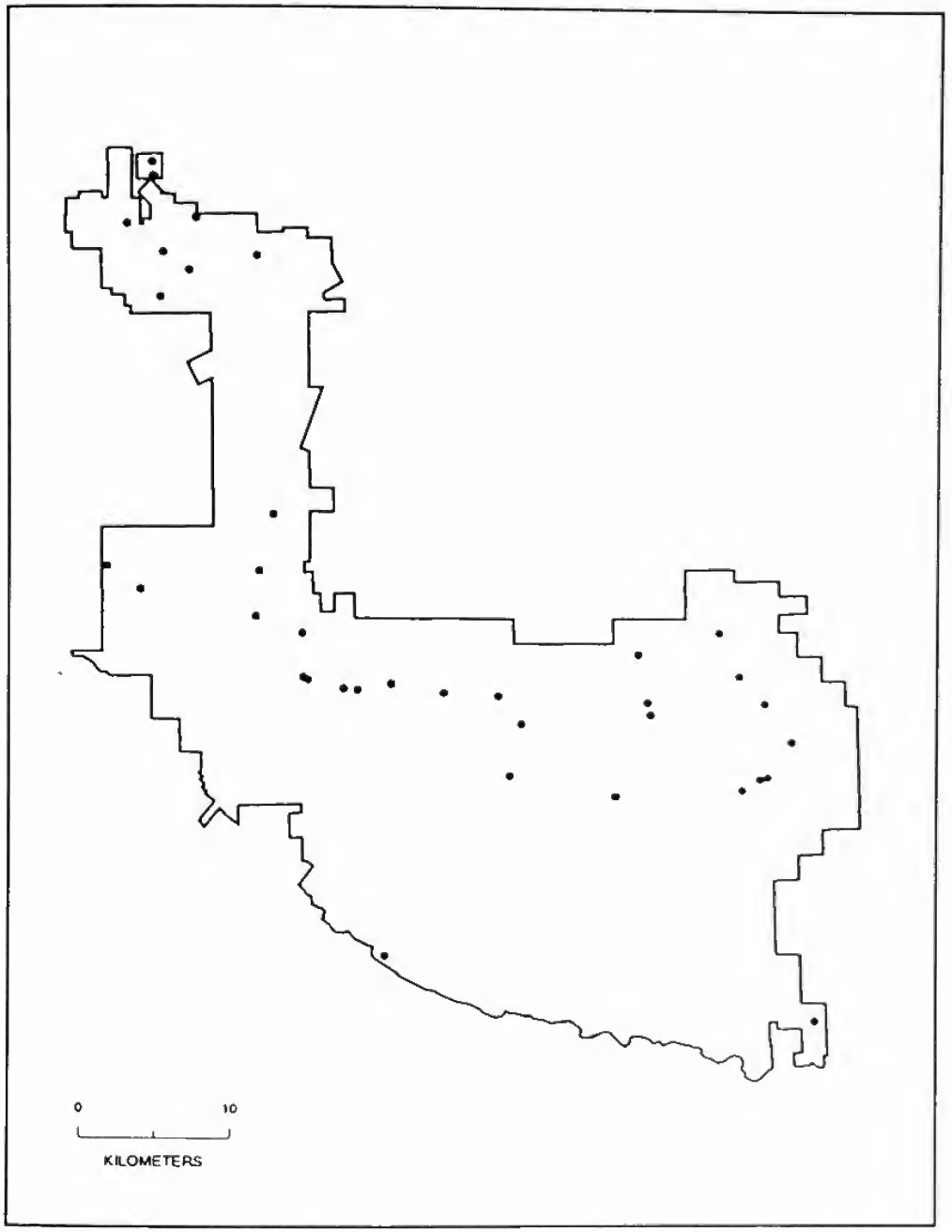

Figure 36. Localities of known specimens of *Chaetodipus nelsoni* from Big Bend Ranch State Park, Texas.

of February through July reported by Schmidly (1977*a*), with the exception of the size of testes observed in August. Enlarged testes measuring 7 X 3 and 8 X 4 were noted on 17 August, thus indicating that males are active reproductively at this time. This suggests that the breeding season of *C. nelsoni* at BBRSP extends well into August.

C. nelsoni is strictly nocturnal, at which time it forages primarily for seeds (Best, 1994). Seeds gathered by Nelson's pocket mouse in the Big Bend area include those of mesquite, creosote-bush, and prickly pear (Judd, 1967). In addition to seeds, *C. nelsoni* also may consume other plant parts and insects (Best, 1994).

A single annual molt is reported to occur in *C. nelsoni* between May and October (Best, 1994). However, molting adults at BBRSP were observed on 24 February; 18 March; 21, 23, 29, and 30 May; 2, 8, 22, and 27 June; 1, 2, 3, 8, and 24 July, 17 August, 17 November, and 3 December. It is possible that these observations are due to a single annual molt that occurs at various times throughout the year, or two seasonal molts, one during spring and the other during fall.

Other species of rodents taken at the same localities as *C. nelsoni* at BBRSP included *Perognathus flavus*, *Chaetodipus eremicus*, *C. intermedius*, *Dipodomys merriami*, *Reithrodontomys fulvescens*, *Peromyscus eremicus*, *P. leucopus*, *P. pectoralis*, and *Neotoma micropus*. See the account on *C. eremicus* for a discussion on the sympatry of *C. eremicus*, *C. intermedius*, and *C. nelsoni*.

Mites on the tail were the only parasites found in association with specimens of *C. nelsoni* from BBRSP. Other ectoparasites previously reported from *C. intermedius* include ticks and fleas. No endoparasites have been reported from *C. nelsoni* (Best, 1994).

Comments.— The subspecies of *C. nelsoni* that occurs at BBRSP is *C. n. canescens* (Merriam, 1904). See the account on *Chaetodipus eremicus* for the etymology of the generic name. The specific epithet *nelsoni* refers to Nelson's (Stangl et al., 1993).

Specimens Examined (74).— Presidio Co.: BBRSP, UTM coordinates: 13 573986E 3270053N, 2; BBRSP, UTM coordinates: 13 575323E 3292088N, 3; BBRSP, UTM coordinates: 13 576206E 3268568N, 1; BBRSP, UTM coordinates: 13 576947E 3295987N, 1; BBRSP, UTM coordinates: 13 576985E 3295102N, 3; BBRSP, UTM coordinates: 13 577120E 3295040N, 3; BBRSP, UTM coordinates: 13 577526E 3287386N, 1; BBRSP, UTM coordinates: 13 577690E 3290260N, 2; BBRSP, UTM coordinates: 13 579410E 3289121N, 2; BBRSP, UTM coordinates: 13 579859E 3292474N, 1; BBRSP, UTM coordinates: 13 583788E 3266885N, 1; BBRSP, UTM coordinates: 13 583846E 3290112N, 1; BBRSP, UTM coordinates: 13 584021E 3269813N, 2; BBRSP, UTM coordinates: 13 584964E 3273523N, 1; BBRSP, UTM coordinates: 13 586886E 3265832N, 1; BBRSP, UTM coordinates: 13 586978E 3262992N, 4; BBRSP, UTM coordinates: 13 587302E 3262817N, 1; BBRSP, UTM coordinates: 13 589699E 3262276N, 3; BBRSP, UTM coordinates: 13 590643E 3262195N, 2; BBRSP, UTM coordinates: 13 592496E 3244969N, 6; BBRSP, UTM coordinates: 13 592858E 3262597N, 3; BBRSP, UTM coordinates: 13 596255E 3262051N, 1; BBRSP, UTM coordinates: 13 599751E 3261864N, 1; BBRSP, UTM coordinates: 13 600518E 3256679N, 4; BBRSP, UTM coordinates: 13 601273E 3260059N, 3; BBRSP, UTM coordinates: 13 607355E 3255359N, 1; BBRSP, UTM coordinates: 13 608747E 3264582N, 1; BBRSP, UTM coordinates: 13 609405E 3261495N, 1; BBRSP, UTM coordinates: 13 609611E 3260698N, 1; BBRSP, UTM coordinates: 13 614094E 3266037N, 1; BBRSP, UTM coordinates: 13 615504E 3263238N, 2; BBRSP, UTM coordinates: 13 615747E 3255837N, 4; BBRSP, UTM coordinates: 13 616984E 3256548N, 2. Brewster Co.: BBRSP, UTM coordinates: 13 617281E 3261484N, 1; BBRSP, UTM coordinates: 13 617505E 3256674N, 2; BBRSP, UTM coordinates: 13 619125E 3258986N, 2; BBRSP, UTM coordinates: 13 620694E 3240946N, 3.

Dipodomys merriami Mearns, 1890
Merriam's kangaroo Rat

Description.— *Dipodomys merriami* is a large heteromyid that is buffy-brown with washed gray above, and white at the flanks and below. The face is white with dark markings. The tail is long and tufted, and the ears are short. Each hind foot of this kangaroo rat has only four toes. The dental formula for *D. merriami* is: i 1/1, c 0/0, p 1/1, m 3/3, total 20.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 248.0 (94, 226-279, 9.8); length of tail vertebrae, 144.9 (94, 129-165, 7.5); length of hind foot, 38.3 (112, 34-41, 1.2); length of ear from notch, 13.6 (112, 11-15, 0.8); weight, 39.8 (99, 29-50, 4.5); greatest length of skull, 36.39 (20, 35.09-37.51, 0.58). Males are significantly larger than females (Best, 1993).

D. merriami is similar in appearance to *D. ordii*, the only other kangaroo rat known from BBRSP. However, the two can be differentiated easily on the basis of the number of toes present on each hind foot; *D. merriami* has four, whereas *D. ordii* has five.

Distribution.— *D. merriami* ranges from central Mexico, northwestward through southwestern Texas, across the southern southwestern United States, and up into southern California and western Nevada (Schmidly et al., 1993). At BBRSP, this kangaroo rat is known from throughout most of the park, but apparently is absent from areas along the Rio Grande (Fig. 37)

Natural History.— With a relative abundance index of 1.076, *D. merriami* was the second most frequently encountered rodent at BBRSP. This kangaroo rat accounted for 16.2 percent of all rodents captured. It is reported as one of the most common rodents of the Trans-Pecos deserts (Schmidly, 1977*a*), and that undoubtedly is the situation at BBRSP.

D. merriami is reported to be a habitat generalist, but seems to prefer scrub habitats (Schmidly, 1977*a*). At BBRSP, this kangaroo rat was taken in all major habitat types, and trap success indicated that it did, in fact, prefer desert scrub over both grassland and riparian habitats (P=0.006 and P<0.001, respectively). Next to desert scrub, *D. merriami* preferred grassland over riparian habitats (P<0.001). In comparison to juniper roughlands, capture rates for this species were higher in both desert scrub and grassland habitats, but lower in riparian habitat. However, due to the small area of juniper roughlands, sample sizes from this habitat type were insufficient for statistical comparisons. In addition to tolerating various vegetation-defined habitats, *D. merriami* also seems catholic regarding the substrate, were it resides. It is thought to succeed equally well on sand, clay, gravelly soils, and rocks. However, in places where *D. merriami* and *D. ordii* are sympatric, the former seems to restrict itself to hard, rocky, or gravelly soils, whereas the latter is limited to sandy situations (Davis and Schmidly, 1994). Even though both of these kangaroo rats are known from BBRSP, *D. merriami* frequently was taken in both rocky and sandy situations. Apparently because *D. ordii* is so rare in the park (see the following account), this displacement effect has not occurred.

D. merriami is not reported to enter seasonal torpor (Reichman and Price, 1993). During this study, Merriam's kangaroo rat was taken during every month, thus verifying that it is active throughout the year at BBRSP.

In the Trans-Pecos, gravid females previously have been reported from August through March, with an average litter size varying from 2.3 to 2.8, depending on the season (Schmidly, 1977*a*). During this study, 12 pregnant females carrying from one to three embryos (mean, 2.2) were examined from mid-April to mid-October. Pregnant females (with number of embryos and corresponding crown-rump lengths in parentheses) were examined on the following dates: 11 April (2 embryos, crown-rump length, 9), 2 May (2 embryos, crown-rump length, 15), 14 May (1 embryo, crown-rump length, 10), 23 May (2 embryos, crown-rump length, 10), 26 May (3 embryos, crown-rump length, 5), 22 June (2 embryos, crown-rump length, 9), 2 August (3 embryos, crown-rump length, 18), 5 August (2 embryos, crown-rump length, 20; 2 embryos, crown-rump length, 25), 11 October (2 embryos, crown-rump length, 16), 12 October (2 embryos, crown-rump length, 9; 3 embryos, crown-rump length, 11). Juveniles were observed in the population on 11 April, 14 May, and 3 and 28 June. Subadults were noted on 11 April and 31 May. Testicular measurements of adult males ranged as follows: January, 11 X 6 to 12 X 6; February, 7 X 4 to 12 X 6; March, 9 X 5; April, 11 X 6 to 12 X 6; May, 10 X 5 to 14 X 7; June, 10 X 5 to 12 X 6; July, 9 X 5 to 12 X 6; August, 9 X 6 to 11 X 5; October, 10 X 5 to 12 X 6; November, 5 X 3 to 10 X 5; December, 7 X 3. These data from BBRSP, coupled with those reported by Schmidly (1977*a*), suggest that in the Big Bend area, *D merriami* breeds throughout the year.

Being nocturnal, *D. merriami* forages at night primarily for seeds. Individuals tend to be more active throughout warm nights than on cold nights, and females are more active when pregnant (Reichman and Price, 1993). Merriam's kangaroo rat mostly feeds on seeds, but will consume green vegetation and insects (Davis

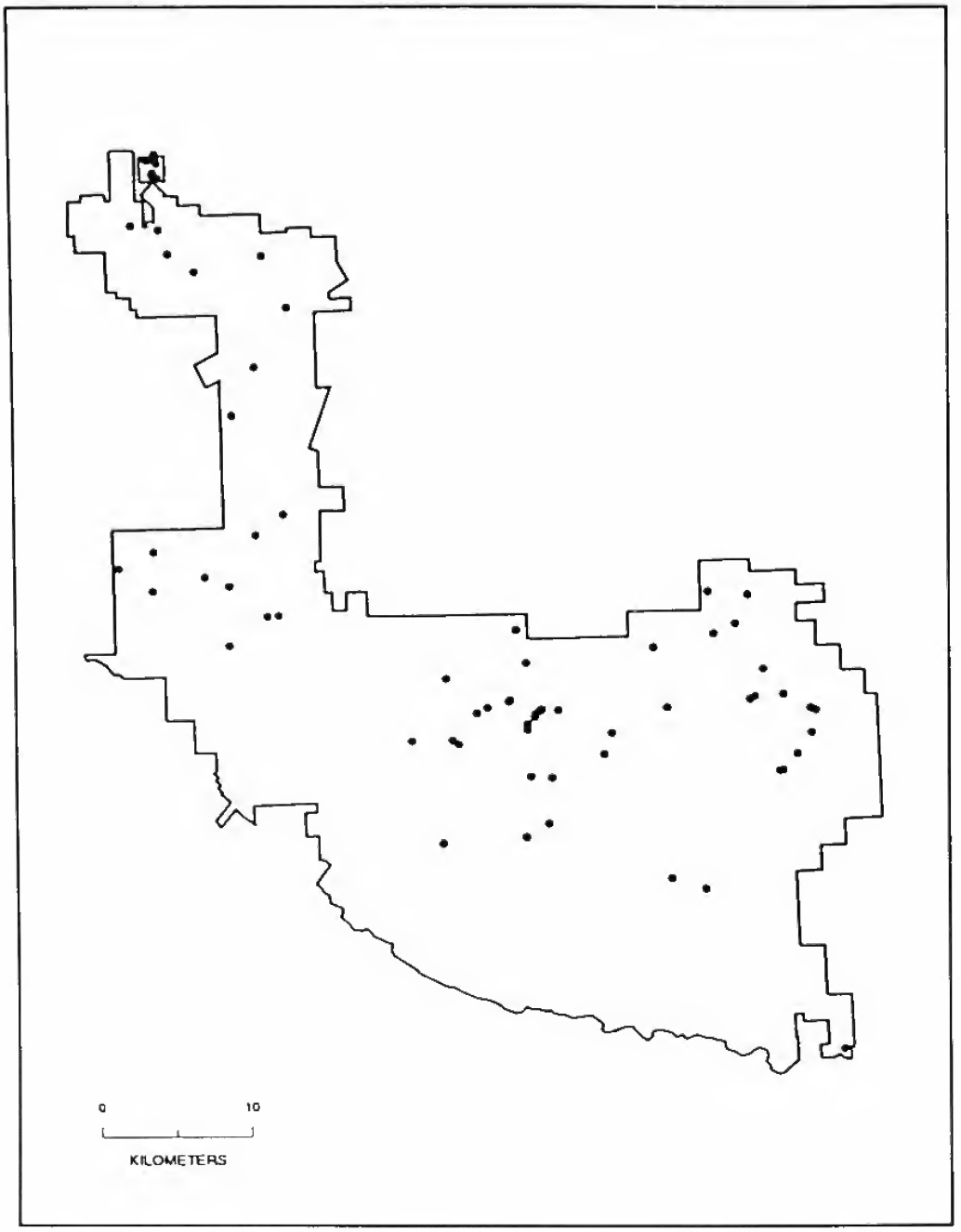

Figure 37. Localities of known specimens of *Dipodomys merriami* from Big Bend Ranch State Park, Texas.

and Schmidly, 1994). An individual taken at BBRSP during this study had cheek pouches full of creosote-bush seeds. Food items most often are gathered from the ground, but there is evidence to suggest that this kangaroo rat occasionally may climb vegetation while foraging (Reichman and Price, 1993).

Little is known about the molting process in *D. merriami*. During this study, adults undergoing seasonal molting were observed during all months excluding April, suggesting that this species may molt more than once a year.

Other species of rodents taken at the same localities as *D. merriami* at BBRSP included *Spermophilus spilosoma*, *Thomomys bottae*, *Perognathus flavus*, *Chaetodipus eremicus*, *C. hispidus*, *C. intermedius*, *C. nelsoni*, *Reithrodontomys fulvescens*, *R. megalotis*, *Peromyscus eremicus*, *P. leucopus*, *P. maniculatus*, *P. pectoralis*, *Onychomys arenicola*, *Neotoma albigula*, *N. mexicana*, and *N. micropus*.

Ectoparasites found on specimens of *D. merriami* from BBRSP included ticks and fleas. In addition, this kangaroo rat is known to be infested with several species of mites. The small intestine of one individual taken from BBRSP was loaded with an undetermined species of cestode. Other endoparasites reported from *D. merriami* include protozoans and nematodes. The pathogenic fungus *Coccidioides immitis* is known to infect *D. merriami* (Whitaker et al., 1993).

Comments.— The subspecies of *D. merriami* at BBRSP is *D. m. ambiguus* Merriam, 1890. The generic name *Dipodomys* is derived from the Greek "dis," "pous," and "mys," which translate to twice, foot, and mouse, respectively. The specific epithet *merriami* refers to Merriam's (Stangl et al., 1993).

Specimens Examined (123).— Presidio Co.: BBRSP, UTM coordinates: 13 573986E 3270053N, 1; BBRSP, UTM coordinates: 13 575323E 3292088N, 1; BBRSP, UTM coordinates: 13 576206E 3268568N, 1; BBRSP, UTM coordinates: 13 576311E 3271128N, 1; BBRSP, UTM coordinates: 13 576390E 3296223N, 1; BBRSP, UTM coordinates: 13 576773E 3295277N, 1; BBRSP, UTM coordinates: 13 576796E 3295418N, 1; BBRSP, UTM coordinates: 13 576836E 3296251N, 2; BBRSP, UTM coordinates: 13 576846E 3296245N, 3; BBRSP, UTM coordinates: 13 576931E 3296613N, 1; BBRSP, UTM coordinates: 13 576969E 3296359N, 1; BBRSP, UTM coordinates: 13 576970E 3296222N, 3; BBRSP, UTM coordinates: 13 577066E 3296038N, 2; BBRSP, UTM coordinates: 13 577106E 3291796N, 1; BBRSP, UTM coordinates: 13 577120E 3295100N, 2; BBRSP, UTM coordinates: 13 577690E 3290260N, 1; BBRSP, UTM coordinates: 13 579410E 3289121N, 1; BBRSP, UTM coordinates: 13 579684E 3269447N, 4; BBRSP, UTM coordinates: 13 581230E 3264998N, 1; BBRSP, UTM coordinates: 13 581288E 3268847N, 1; BBRSP, UTM coordinates: 13 581659E 3279903N, 1; BBRSP, UTM coordinates: 13 583096E 3272189N, 1; BBRSP, UTM coordinates: 13 583205E 3282984N, 1; BBRSP, UTM coordinates: 13 583788E 3266885N, 1; BBRSP, UTM coordinates: 13 583846E 3290112N, 1; BBRSP, UTM coordinates: 13 584531E 3266930N, 1; BBRSP, UTM coordinates: 13 584964E 3273523N, 1; BBRSP, UTM coordinates: 13 585434E 3286791N, 1; BBRSP, UTM coordinates: 13 595478E 3262749N, 1; BBRSP, UTM coordinates: 13 595848E 3258744N, 1; BBRSP, UTM coordinates: 13 596232E 3258492N, 1; BBRSP, UTM coordinates: 13 597424E 3260494N, 1; BBRSP, UTM coordinates: 13 598125E 3260852N, 1; BBRSP, UTM coordinates: 13 599495E 3261227N, 6; BBRSP, UTM coordinates: 13 599607E 3261323N, 1; BBRSP, UTM coordinates: 13 599992E 3265848N, 2; BBRSP, UTM coordinates: 13 600515E 3252408N, 1; BBRSP, UTM coordinates: 13 600634E 3263701N, 1; BBRSP, UTM coordinates: 13 600684E 3259365N, 1; BBRSP, UTM coordinates: 13 600694E 3259751N, 1; BBRSP, UTM coordinates: 13 600868E 3256344N, 7; BBRSP, UTM coordinates: 13 601154E 3260197N, 2; BBRSP, UTM coordinates: 13 601221E 3260400N, 1; BBRSP, UTM coordinates: 13 601508E 3260673N, 3; BBRSP, UTM coordinates: 13 601560E 3260590N, 5; BBRSP, UTM coordinates: 13 601622E 3260685N, 1; BBRSP, UTM coordinates: 13 601973E 3253265N, 1; BBRSP, UTM coordinates: 13 60211E 3256243N, 2; BBRSP, UTM coordinates: 13 602666E 3260640N, 3; BBRSP, UTM coordinates: 13 605576E 3257735N, 1; BBRSP, UTM coordinates: 13 606085E 3259112N, 1; BBRSP, UTM coordinates: 13 608747E 3264582N, 2; BBRSP, UTM coordinates: 13 609611E 3260698N, 1; BBRSP, UTM coordinates: 13 612321E 3268161N, 3; BBRSP, UTM coordinates: 13 612683E 3265440N, 1; BBRSP, UTM coordinates: 13 614094E 3266037N, 4; BBRSP, UTM coordinates: 13 614933E 3267912N, 5; BBRSP, UTM coordinates: 13 615063E 3261184N, 1; BBRSP, UTM coordinates: 13 615371E 3261358N, 2; BBRSP, UTM coordinates: 13 615951E 3263099N, 2; BBRSP, UTM coordinates: 13 616984E 3256548N, 1; BBRSP, 0.75 mi. SW Aqua Adentro, 2 (SRSU); BBRSP, Rancherias Springs, 1 (SRSU); BBRSP, Madrid Ranch, Chorro Canyon, 15 mi. N Lajitas, 1 (SRSU); BBRSP, 15 mi. NW Lajitas, 1 (SRSU). Brewster Co.: BBRSP, UTM coordinates: 13 617223E 3256581N, 2; BBRSP, UTM coordinates: 13 617281E 3261484N, 4; BBRSP, UTM coordinates: 13 618185E

3257611N, 2; BBRSP, UTM coordinates: 13 619081E 3260561N, 1; BBRSP, UTM coordinates: 13 619125E 3258986N, 1; BBRSP, UTM coordinates: 13 619408E 3260416N, 1; BBRSP, UTM coordinates: 13 620927E 3238664N, 2.

Dipodomys ordii Woodhouse, 1853
Ord's Kangaroo Rat

Description.— *Dipodomys ordii* is a large heteromyid that is pale buff with washed gray above, and white at the flanks and below. The face is white with dark markings. The tail is long and tufted, and the ears are short. The hind feet of this kangaroo rat have five toes. The dental formula for *D. ordii* is: i 1/1, c 0/0, p 1/1, m 3/3, total 20.

The external measurements of an adult specimen from BBRSP are: total length, 230; length of tail vertebrae, 138; length of hind foot, 37; length of ear from notch, 13; weight, 43.4. Garrison and Best (1990) list the mean greatest length of skull measurement for male *D. ordii* throughout its range as 39.4. Males are significantly larger than females (Garrison and Best, 1990).

D. ordii closely resembles *D. merriami*, but can be distinguished easily as described in the account of the latter.

Distribution.— *D. ordii* ranges from central Mexico, northward throughout much of the western United States, and into southern Alberta and Saskatchewan (Garrison and Best, 1990). At BBRSP, it is known only from a single locality in the Fresno Canyon area (Fig. 38).

Natural History.— No specimens of *D. ordii* were acquired during this study, and this kangaroo rat is known from BBRSP on the basis of only a single specimen. Therefore, *D. ordii* should be considered a rare inhabitant of BBRSP. Apparently, the reproductive rate of *D. ordii* decreases in response to prolonged drought (Schmidly, 1977*a*), as was the condition at BBRSP during the duration of this study. Reproductive activity is then thought to rebound following periods of favorable precipitation and subsequent increase in food supply (Schmidly, 1977*a*). Although Ord's kangaroo rat is not common in much of the Trans-Pecos (Schmidly, 1977*a*), it has been reported as common in parts of Big Bend National Park (Jones et al., 1993), and I expect numbers of this rodent at BBRSP to increase following the drought.

The habitat type from which the specimen of *D. ordii* from BBRSP was taken is unknown. Of the habitat types that occur in the park, this kangaroo rat is known to occur in scrubland, grassland, and juniper-associated areas (Garrison and Best, 1990). However, it seems that the type of vegetative community in which *D. ordii* resides is less important than the substrate. It shows a strong preference for fine, sandy soils (Garrison and Best, 1990), and at BBRSP is a potential inhabitant wherever these substrata exist.

The single specimen of *D. ordii* known from BBRSP was collected in November. This kangaroo rat does not hibernate (Garrison and Best, 1990) and undoubtedly is active throughout the year in the park.

Most male Ord's kangaroo rats are capable of breeding year round (Garrison and Best, 1990), but the breeding period of *D. ordii* in the Big Bend area apparently is restricted to August through February. Schmidly (1977*a*) reported that females give birth to litters of one to five young (mean, 2.75), and Alcorn (1941) suggested that more than one litter a year might be produced.

D. ordii is a nocturnal granivore, foraging at night primarily for seeds of grasses and forbs (Garrison and Best, 1990). Most seeds are gathered from the ground (Reichman and Price, 1993), but this kangaroo rat has been documented to climb a sunflower plant (*Helianthus* sp.) as high as one meter, clip off the flowering head, and return to the ground to feed on it (Lemen and Freeman, 1985). In addition to seeds, *D. ordii* also consumes other plant parts, as well as various arthropods (Flake, 1973).

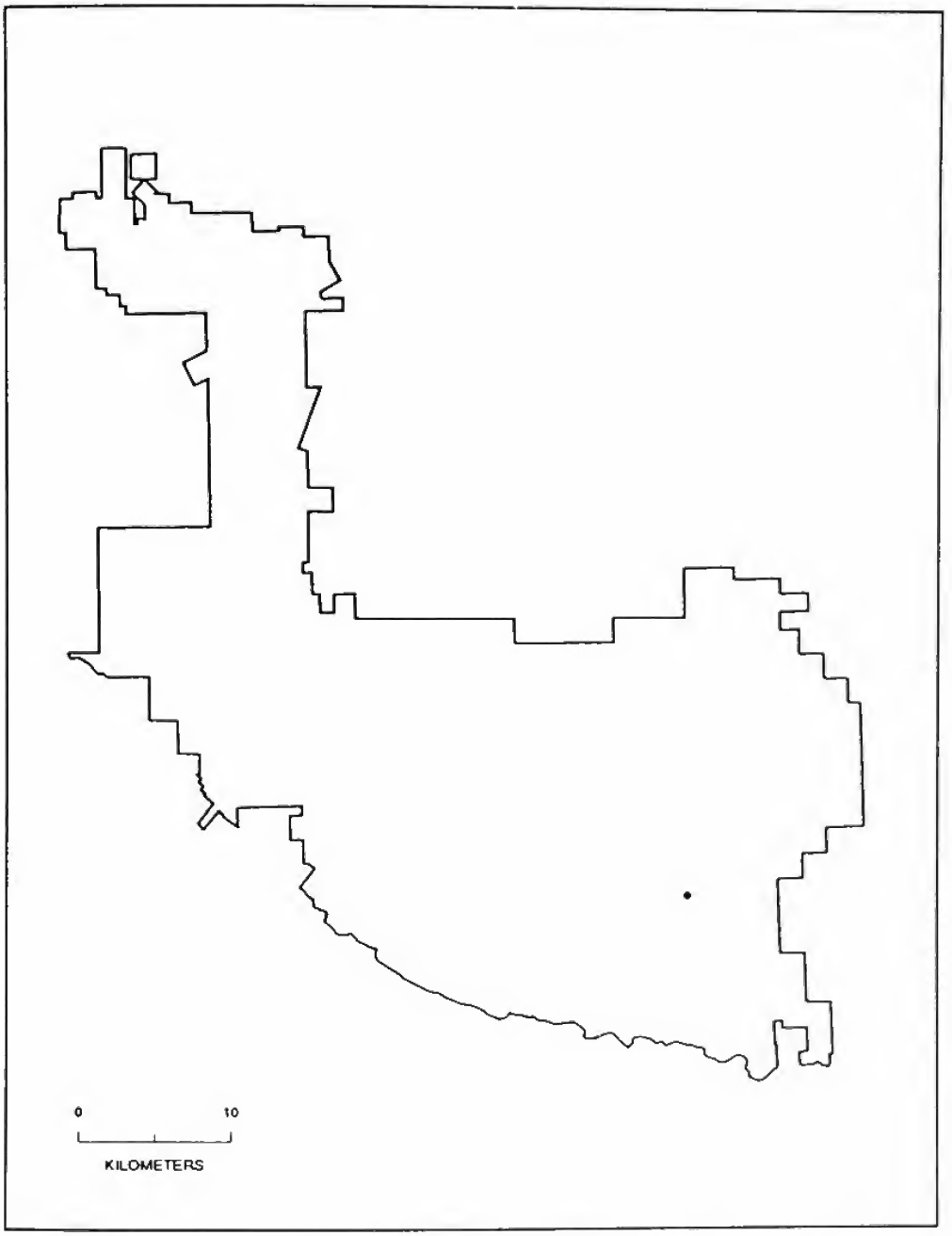

Figure 38. Localities of known specimens of *Dipodomys ordii* from Big Bend Ranch State Park, Texas.

Nothing is known regarding annual molting in *D. ordii*.

Ectoparasites documented to infest *D. ordii* include mites, ticks, sucking lice, and fleas. Internal parasites known from *D. ordii* include protozoans, cestodes, and nematodes. The bacteria that cause plague (*Yersinia pestis*) and tularemia (*Francisella tularensis*), and the rickettsia responsible for Rocky Mountain Spotted Fever (*Rickettsia rickettsii*) and Q-fever (*Coxiella burnetii*) are known to infect *D. ordii* (Whitaker et al., 1993).

Comments.— The subspecies of *D. ordii* that occurs at BBRSP probably is *D. o. obscurus* (J. A. Allen, 1903). See the account on *Dipodomys merriami* for the etymology of the generic name. The specific epithet *ordii* refers to Ord's (Stangl et al., 1993).

Specimens Examined (1).— Presidio Co.: BBRSP, 15 mi. NW Lajitas, 1 (SRSU).

Family Castoridae (Beavers)

Castor canadensis Kuhl, 1820
American Beaver

Description.— *Castor canadensis* is a large rodent with long, coarse dorsal pelage that is dark to reddish brown in color. The hind feet of this semi-aquatic mammal are webbed, and its tail is naked, scaly, and flattened dorsoventrally. The dental formula for *C. canadensis* is: i 1/1, c 0/0, p 1/1, m 3/3, total 20.

No measurements of *C. canadensis* from BBRSP were obtained. Schmidly (1977*a*) lists the following average external measurements for specimens from the Trans-Pecos: total length, 1070; length of tail vertebrae, 400; length of hind foot, 174; weight, 20 kg. Jenkins and Busher (1979) list the range for ear length and greatest length of skull measurements for the species in general as 23 to 29, and 121 to 146, respectively. *C. canadensis* is not sexually dimorphic (Jenkins and Busher, 1979).

C. canadensis is distinguished easily from all other mammals that occur at BBRSP on the basis of its size, webbed hind feet, unique tail, and aquatic habits.

Distribution.— The range of *C. canadensis* extends from northern Mexico, northward throughout most of North America (Jenkins and Busher, 1979). There are no specimens from BBRSP, however beavers have been observed at sites along the Rio Grande, including Arenosa (this study), Colorado Canyon (Scudday, 1976*c*), and the Lajitas area (Schmidly, 1977*a*).

Natural History.— No beavers were collected during this study, and only a single individual was observed. However, both Scudday (1976*c*) and Schmidly (1977*a*) suggest that this rodent is rather common at some places in the Big Bend area.

At BBRSP, the beaver is restricted to water-associated habitats along the Rio Grande. Vegetation in these areas typically consists of salt cedar, giant reed, tree tobacco, mesquite, willow, and various grasses. Somewhat uncharacteristic of beavers, the subspecies of *C. canadensis* that occurs at BBRSP does not build elaborate dams. Instead, it digs burrows into the banks of the Rio Grande at about the level of the water (Schmidly, 1977*a*).

The single beaver observed during this study was sighted in December. *C. canadensis* does not hibernate, and should be considered active throughout the year at BBRSP.

Little is known regarding the reproductive biology of beavers in the Big Bend area. Juveniles that appeared to be a few weeks old have been sighted as early as March (Schmidly, 1977*a*). Given a gestation period of about 107 days (Wilsson, 1971), these individuals probably were conceived in October or November. *C. canadensis* in general usually breeds in January or February, with parturition occurring in May or June. However, this species has been documented to breed as late as November. Females give birth usually to three or four young once a year (Jenkins and Busher, 1979).

C. canadensis mainly is crepuscular and nocturnal, but may be active during the day as well (Jones and Birney, 1988). It is an obligate vegetarian , feeding on the leaves, twigs, and bark of a variety of plants (Jenkins and Busher, 1979). Along the Rio Grande, beavers seem to prefer willow, although desert willow, mesquite, and tree tobacco also are consumed (Schmidly, 1977*a*). The digestion of these woody materials is enhanced by a prominent cardiogastric gland in the stomach, glandular digestive areas elsewhere, and a large

cecum containing cellulose-degrading microbes (Hill, 1982).

No data regarding the process of seasonal molting are available.

Ectoparasites known from *C. canadensis* include ticks. Endoparasites of beavers include protozoans, trematodes, and nematodes. Epidemics of tularemia due to infection with the bacterium *Francisella tularensis* have been documented in beavers (Jenkins and Busher, 1979).

Comments.— The subspecies of *C. canadensis* at BBRSP is *C. c. mexicanus* Bailey, 1913. The generic name *Castor* is derived from the Greek "kastor," which translates to beaver. The specific epithet *canadensis* refers to of Canada (Stangl et al., 1993).

Specimens Examined (0).

Family Muridae (Mice and Rats)

Reithrodontomys fulvescens J. A. Allen, 1894
Fulvous Harvest Mouse

Description.— *Reithrodontomys fulvescens* is a small mouse with a dorsal pelage that is ochraceous buff washed with dark brown above, and golden buff on the sides. The tail of this mouse is longer than the head and body, scaly, and not bicolored. The ears are short, each with reddish-orange hairs on the inside. As in all members of the genus, the anterior surface of each upper incisor is grooved. The dental formula for *R. fulvescens* is: i 1/1, c 0/0, p 0/0, m 3/3, total 16.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 159.3 (8, 147-178, 10.7); length of tail vertebrae, 91.0 (8, 86-98, 3.9); length of hind foot, 19.0 (8, 18-20, 7.6); length of ear from notch, 13.8 (8, 12-16, 1.2); weight, 10.2 (7, 8.0-12, 1.3); greatest length of skull, 21.21 (8, 20.62-21.83, 0.43). I know of no reports pertaining to secondary sexual dimorphism in the fulvous harvest mouse.

R. fulvescens can be confused easily with *R. megalotis*. The two, however, can be separated on the basis of color, tail characteristics, and dentition. *R. fulvescens* has bright, fulvous coloration on the sides; the tail is relatively naked and scaly, not bicolored, and much longer than the head and body; and the last lower molar typically has an S-shaped dentine. In contrast, *R. megalotis* is buffy brown on the sides; the tail is covered with short hairs, indistinctly bicolored, and about the same length or shorter than the head and body; and the last lower molar has C-shaped dentine. *R. fulvescens* is distinguished easily from all other murids at the park, by the grooved upper incisors.

Distribution.— *R. fulvescens* ranges from Central America, northward throughout most of Mexico, and into parts of the southwestern and south-central United States (Spencer and Cameron, 1982). At BBRSP, it is known from the Las Quevas and Sauceda areas, as well as from the Solitario (Fig. 39). Specimens taken from Las Quevas define the southwestern limits of the range of this species in the Trans-Pecos.

Natural History.— The relative abundance index of *R. fulvescens* at BBRSP was 0.065. This harvest mouse accounted for 1.0 percent of all rodents taken. These data indicate that *R. fulvescens* is uncommon at BBRSP. The park is situated near the western limits of the distribution of this species in the Trans-Pecos (Schmidly, 1977*a*), which may account for its rarity.

R. fulvescens has been documented to favor rough grasslands often associated with shrubs (Hooper, 1952; Packard, 1968; Schmidly, 1977*a*). However, at BBRSP, this species was taken only in riparian habitat dominated by willow, cottonwood, false willow, and deer grass, and in desert scrub dominated by mesquite. Of these two habitats, *R. fulvescens* significantly favored the riparian woodland over desert scrub (P=0.001). Blair (1940) trapped fulvous harvest mice in mesquite-associated habitat, but I know of no previous report of this species having an affinity for riparian woodlands.

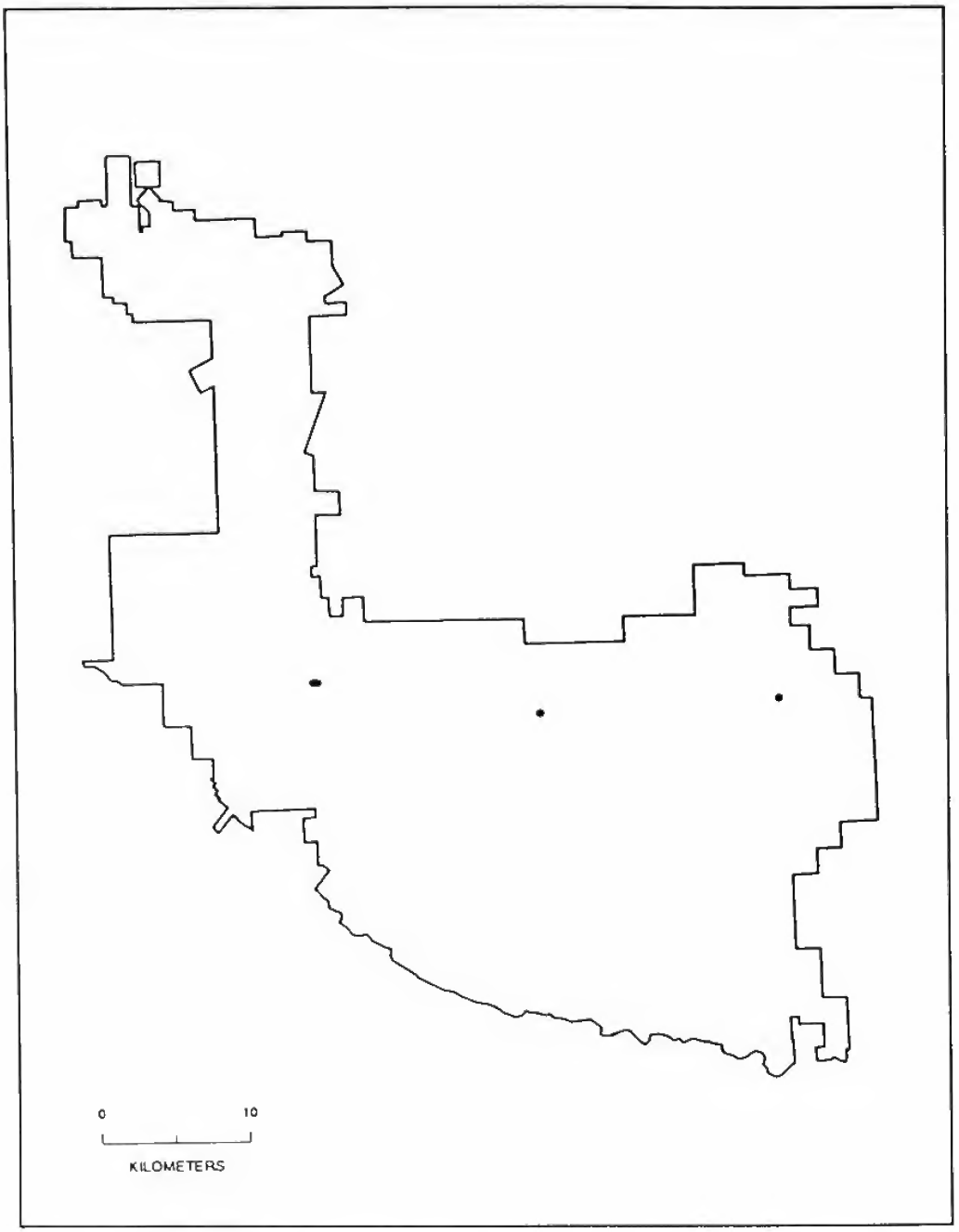

Figure 39. Localities of known specimens of *Reithrodontomys fulvescens* from Big Bend Ranch State Park, Texas.

During this study, *R. fulvescens* was taken only during January, February, and November. However, this harvest mouse is not known to enter seasonal torpor (Davis and Schmidly, 1994) and is assumed to be active throughout the year at BBRSP.

Virtually nothing is known of the reproductive habits of *R. fulvescens* in the Big Bend area. In Texas in general, this harvest mouse reportedly breeds from February through October (Davis and Schmidly, 1994). I examined a single gravid female (3 embryos, crown-rump length, 14) on 10 November. Testicular measurements of males taken on 13 February and 10 November were 4 X 2 and 10 X 5, respectively. Given a gestation period of about 21 days (Davis and Schmidly, 1994), these data suggest that the breeding period in BBRSP may extend well into November (Yancey et al., 1995).

Litter sizes are known to range from two to six (mean, 3-4; Spencer and Cameron, 1982; Davis and Schmidly, 1994). Females may produce two or more litters a year (Packard, 1968).

R. fulvescens is strictly nocturnal at which time it forages for a variety of foods. Seeds and invertebrates seem to constitute the majority of the diet. Fulvous harvest mice are known to forage on the ground as well as up to one meter high in vegetation (Spencer and Cameron, 1982).

Little has been documented on the molting process of adult fulvous harvest mice. During this study, adults undergoing seasonal molting were noted on 10 and 17 November. Hooper (1952) reported evidence of at least one and perhaps two annual molts.

Other species of rodents taken at the same localities as *R. fulvescens* at BBRSP included *Chaetodipus eremicus*, *C. nelsoni*, *Dipodomys merriami*, *Reithrodontomys megalotis*, *Peromyscus leucopus*, *P. maniculatus*, *P. pectoralis*, *Sigmodon hispidus*, and *S. ochrognathus*. The sympatric and syntopic occurrence of *R. fulvescens* and *R. megalotis* is an interesting situation. Such a close ecological association of these two species of harvest mice has not been documented elsewhere in the Big Bend area (Yancey et al., 1995).

No parasites were observed in association with fulvous harvest mice taken at BBRSP. The only parasites previously reported from this mouse are fleas (Spencer and Cameron, 1982).

Comments.— The subspecies of *R. fulvescens* at BBRSP is *R. f. canus* Benson, 1939. The generic name *Reithrodontomys* is derived from the Greek "rheithron," "odous," and "mys," which translate to stream or channel, tooth, and mouse, respectively. The specific epithet *fulvescens* is from the Latin "fulvus," meaning brown (Stangl et al., 1993).

Specimens Examined (8).— Presidio Co.: BBRSP, UTM coordinates: 13 586937E 3262923N, 1; BBRSP, UTM coordinates: 13 587250E 3262918N, 5; BBRSP, UTM coordinates: 13 601619E 3260741N, 1; BBRSP. Brewster Co.: BBRSP, UTM coordinates: 13 617281E 3261418N, 1.

Reithrodontomys megalotis (Baird, 1858)
Western Harvest Mouse

Description.— *Reithrodontomys megalotis* is a small mouse with a pale brown dorsal pelage. The tail is moderate in length (about as long as the head and body), covered with short hairs, and indistinctly bicolored, and the ears are short. The anterior surface of each upper incisor is grooved. The dental formula for *R. megalotis* is: i 1/1, c 0/0, p 0/0, m 3/3, total 16.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 137.4 (11, 125-152, 10.1); length of tail vertebrae, 71.0 (11, 64-79, 4.6); length of hind foot, 17.5 (11, 16-18, 4.6); length of ear from notch, 13.7 (11, 12-15, 0.7); weight, 8.3 (10, 6.5-10, 1.3); greatest length of skull, 20.18 (11, 19.65-20.99, 0.42). There is no evidence of significant sexual dimorphism among western harvest mice (Jones and Mursaloglu, 1961).

R. megalotis is similar in appearance to *R. fulvescens*, but the two can be distinguished as described in the previous account. *R. megalotis* is differentiated from all other murids at BBRSP by the grooved upper incisors.

Distribution.— The range of *R. megalotis* extends from southern Mexico, northward throughout the western and north-central United States (Webster and Jones, 1982). At BBRSP, this mouse is known from the Cienega, Las Quevas, and Sauceda areas, as well as from the Bofecillos Mountains (Fig. 40).

Natural History.— The relative abundance index of *R. megalotis* at BBRSP was determined to be 0.089. It comprised 1.3 percent of all rodents trapped, and therefore, should be regarded as uncommon in the park. This harvest mouse was reported as rather sporadic in northern Big Bend National Park (Jones et al., 1993).

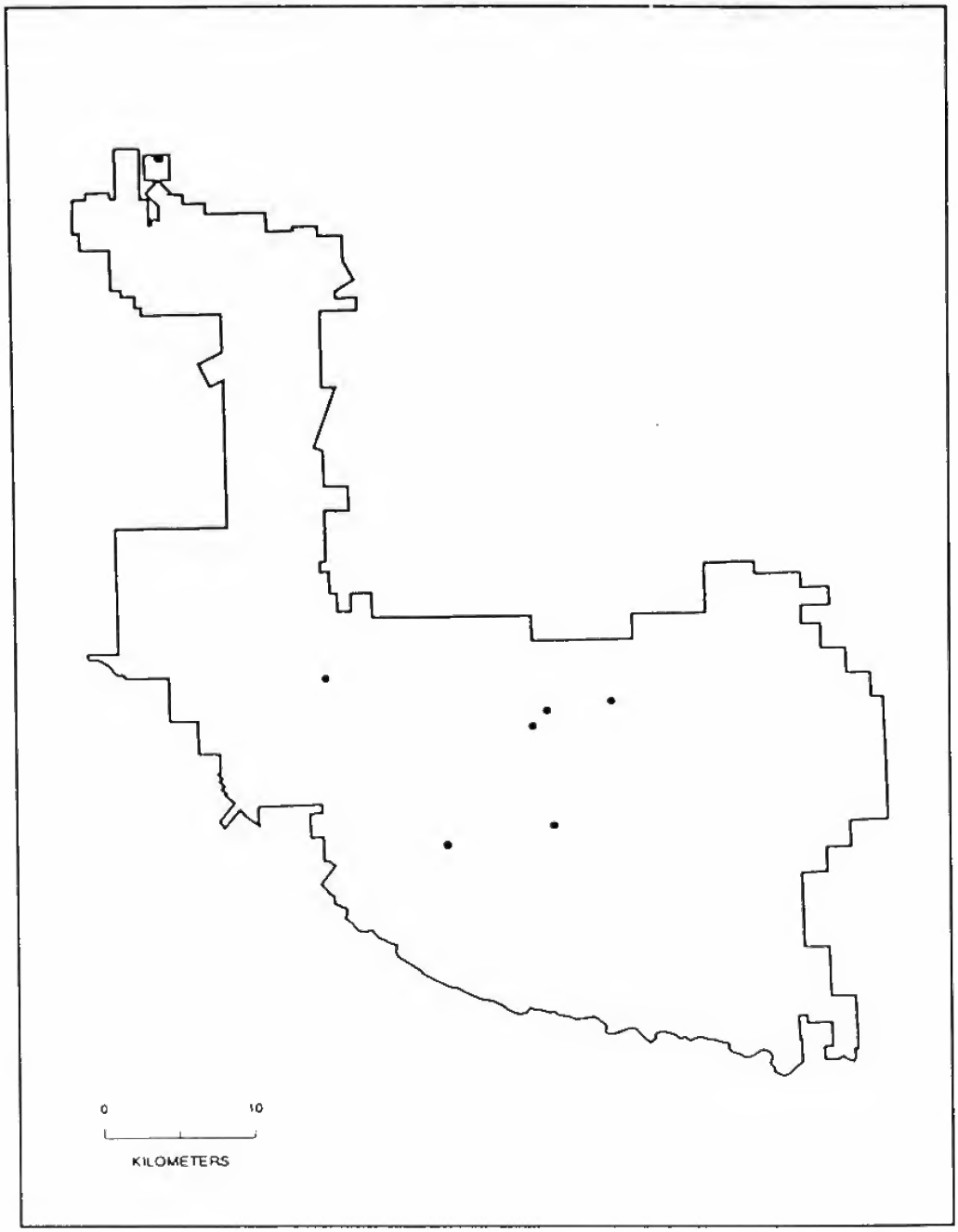

Figure 40. Localities of known specimens of *Reithrodontomys megalotis* from Big Bend Ranch State Park, Texas.

R. megalotis is reported to favor grassland and riparian situations (Webster and Jones, 1982), as well as desert scrub (Jones et al., 1993). At BBRSP, this harvest mouse was acquired from all three of these habitats. There was a significant difference noted among trap success in the three habitats when examined collectively (P=0.043). However their were no differences detected between any two habitats (P=0.37 for desert scrub versus desert grassland; P=0.029 for desert scrub versus riparian; P=0.31 for desert grassland versus riparian).

R. megalotis is known to hibernate in some parts of its range (Webster and Jones, 1982). However, this is not the situation at BBRSP as this mouse was taken during each season of the year.

Most breeding activity of western harvest mice occurs from early spring to late fall (Webster and Jones, 1982), but in the Trans-Pecos, mating may occur throughout the year (Schmidly, 1977*a*). Throughout its range, litter sizes vary from one to nine (Long, 1962), but in the Trans-Pecos, reported extremes are two and five (mean, 3.8). Multiple litters are produced each year (Schmidly, 1977*a*). During this study, a gravid female was observed on 1 April (3 embryos, crown-rump length, 8). Testicular measurements of adult males ranged as follows: January, 5 X 3; February, 3 X 2 to 6 X 4; July, 8 X 5.

R. megalotis is a nocturnal granivore. It forages primarily for seeds, but also will consume other plant material and insects (Webster and Jones, 1982).

Two annual molts are reported to occur in western harvest mice, one in spring, the other in autumn (Jones and Mursaloglu, 1961). During this study, molting adults were taken on 3 and 14 February, and 26 November, indicating that, at BBRSP, the first molt of the year begins in late winter, rather than spring.

Other species of rodents taken at the same localities as *R. megalotis* at BBRSP included *Perognathus flavus*, *Chaetodipus eremicus*, *C. hispidus*, *Dipodomys merriami*, *Reithrodontomys fulvescens*, *Peromyscus eremicus*, *P. leucopus*, *P. maniculatus*, *P. pectoralis*, *Onychomys arenicola*, *Sigmodon hispidus*, *S. ochrognathus*, and *Neotoma micropus*. See the previous account for a discussion on the sympatry of *R. megalotis* and *R. fulvescens*.

Ticks and fleas were observed infesting *R. megalotis* at BBRSP. Additional ectoparasites known from this mouse include numerous species of mites. Endoparasites previously reported from *R. megalotis* include protozoans, cestodes, and nematodes (Webster and Jones, 1982). *R. megalotis* has been shown to harbor hantavirus (Childs et al., 1995).

Comments.— The subspecies of *R. megalotis* at BBRSP is *R. m. megalotis* (Baird, 1858). See the account on *Reithrodontomys fulvescens* for the etymology of the generic name. The specific epithet *megalotis* is from the Greek "megas" and "ous," meaning big and ear, respectively (Stangl et al., 1993).

Specimens Examined (11).— Presidio Co.: BBRSP, UTM coordinates: 13 576836E 3296251N, 1; BBRSP, UTM coordinates: 13 576970E 3296222N, 1; BBRSP, UTM coordinates: 13 587250E 3262918N, 2; BBRSP, UTM coordinates: 13 595150E 3252057N, 1; BBRSP, UTM coordinates: 13 600694E 3259751N, 1; BBRSP, UTM coordinates: 13 601619E 3260741N, 2; BBRSP, UTM coordinates: 13 601973E 3253265N, 1; BBRSP, UTM coordinates: 13 605746E 3261330N, 2.

Peromyscus boylii (Baird, 1855)
Brush Mouse

Description.— *Peromyscus boylii* is a medium-sized mouse with a pale to moderately brown dorsal pelage. The tail of this mouse is longer than the head and body, heavily haired, indistinctly bicolored, and tufted at the tip. The ears are intermediate in length. The ankles are dusky gray, and the soles of the hind feet are furred at the heels. The dental formula for *P. boylii* is: i 1/1, c 0/0, p 0/0, m 3/3, total 16.

No measurements of *P. boylii* from BBRSP were obtained. Cornely et al. (1981) list the following means of external and cranial measurements (with sample size, extremes, and 95% confidence interval in parentheses) of adult specimens taken elsewhere in the Trans-Pecos: total length, 194.0 (6, 183-201, 187.9-200.1); length of tail vertebrae, 100.5 (6, 82-108, 92.6-108.4); length of hind foot, 21.2 (6, 19-22, 20.2-22.1); length of ear from notch, 19.5 (6, 18-22, 18.2-20.8); greatest length of skull, 27.62 (6, 27.15-28.00, 27.36-27.88). Weights of the brush mouse range from 22-36 (Davis and Schmidly, 1994). I know of no reports of marked secondary sexual dimorphism in *P. boylii*.

P. boylii is confused most easily with the other long-tailed *Peromyscus* at BBRSP, *P. eremicus* and *P. pectoralis*. *P. boylii* can be distinguished from *P.*

eremicus by the densely haired and tufted tail, and haired heels, as opposed to the sparsely haired and nontufted tail, and naked heels of *P. eremicus*. In addition, there are three pairs of mammae in female *P. boylii*, whereas there are only two in female *P. eremicus* (the pectoral mammae are lacking). In male *P. boylii*, the glans penis is elongate and rod-shaped, whereas it is vase-shaped in *P. eremicus*. Furthermore, cranial morphology can be used to easily distinguish these two species. In *P. boylii*, the posterior ends of the premaxillae terminate at about the level of the nasals, whereas they extend well beyond the nasals in *P. eremicus*. *P. boylii* can be distinguished from *P. pectoralis* by its densely haired and tufted tail, rather than sparsely haired and nontufted, and by its dusky-colored, rather than white, ankles. In males, baculum morphology can be used to easily separate these two species. The cartilaginous tip of the baculum of *P. boylii* is short and blunt, whereas it is long and pointed in *P. pectoralis*. In addition, cranial morphology varies between these two species. In *P. boylii*, the posterior ends of the nasals terminate in a V-shape, whereas they are relatively blunt in *P. pectoralis*. *P. boylii* is differentiated easily from the other species of *Peromyscus* at BBRSP by having a tail that is longer than the head and body.

Distribution.— *P. boylii* ranges from Central America, northward throughout much of Mexico and across the southwestern United States (Hall, 1981). At BBRSP, this mouse is known only from one locality along the Rio Grande (Fig. 41).

Natural History.— No specimens of *P. boylii* were acquired during this study. Scudday (1976*c*) reported this mouse as fairly common along the Rio Grande in Colorado Canyon. However, I examined these specimens, and all appeared to be either *P. eremicus* or *P. pectoralis*. Only a single verified specimen of the brush mouse taken in 1966 exists from BBRSP. Based on this information, *P. boylii* should be considered among the rarest of rodents at BBRSP.

The specimen of *P. boylii* taken from BBRSP was acquired from a rocky hillside above the Rio Grande. This mouse is reported to favor rocky, montane areas with oak, piñon, juniper, and brush (Borell and Bryant, 1942; Schmidly, 1977*a*). In Big Bend National park, it is most common above 1800 m (Schmidly, 1977*a*). The lack of this type of habitat from BBRSP probably accounts for its scarcity there.

The specimen of *P. boylii* from BBRSP was taken in May. This mouse does not enter seasonal torpor and is active throughout the year (Davis and Schmidly, 1994).

No reproductive data are available for *P. boylii* from BBRSP. Elsewhere in the Trans-Pecos, the breeding period of brush mice is thought to extend from March through August (Cornely et al., 1981). Females give birth to litters of three to five (mean, 4) young, probably two or more times a year (Schmidly, 1977*a*).

P. boylii is active at night, during which time it forages primarily for plant material. Hackberries, juniper berries, cactus fruits, and acorns are among its favorite foods (Schmidly, 1977*a*).

Little is known of the molting process in *P. boylii*. Cornely et al. (1981) observed adult brush mice molting in June and August.

Ectoparasites known from *P. boylii* include mites, ticks, lice, fleas, and botfly larvae. Endoparasites reported from brush mice include cestodes and nematodes (Whitaker, 1968). *P. boylii* has been implicated as a carrier of pulmonary syndrome hantavirus (Stone, 1993).

Comments.— The subspecies of *P. boylii* at BBRSP is *P. b. rowleyi* (J. A. Allen, 1893). The generic name *Peromyscus* is derived from the Greek "pera" and "myskos," which translate to pouch, and little mouse, respectively. The specific epithet *boylii* refers to Boyle's (Stangl et al., 1993).

Specimens Examined (1).— Presidio Co.: BBRSP, 12 mi. S Redford, 1 (SRSU).

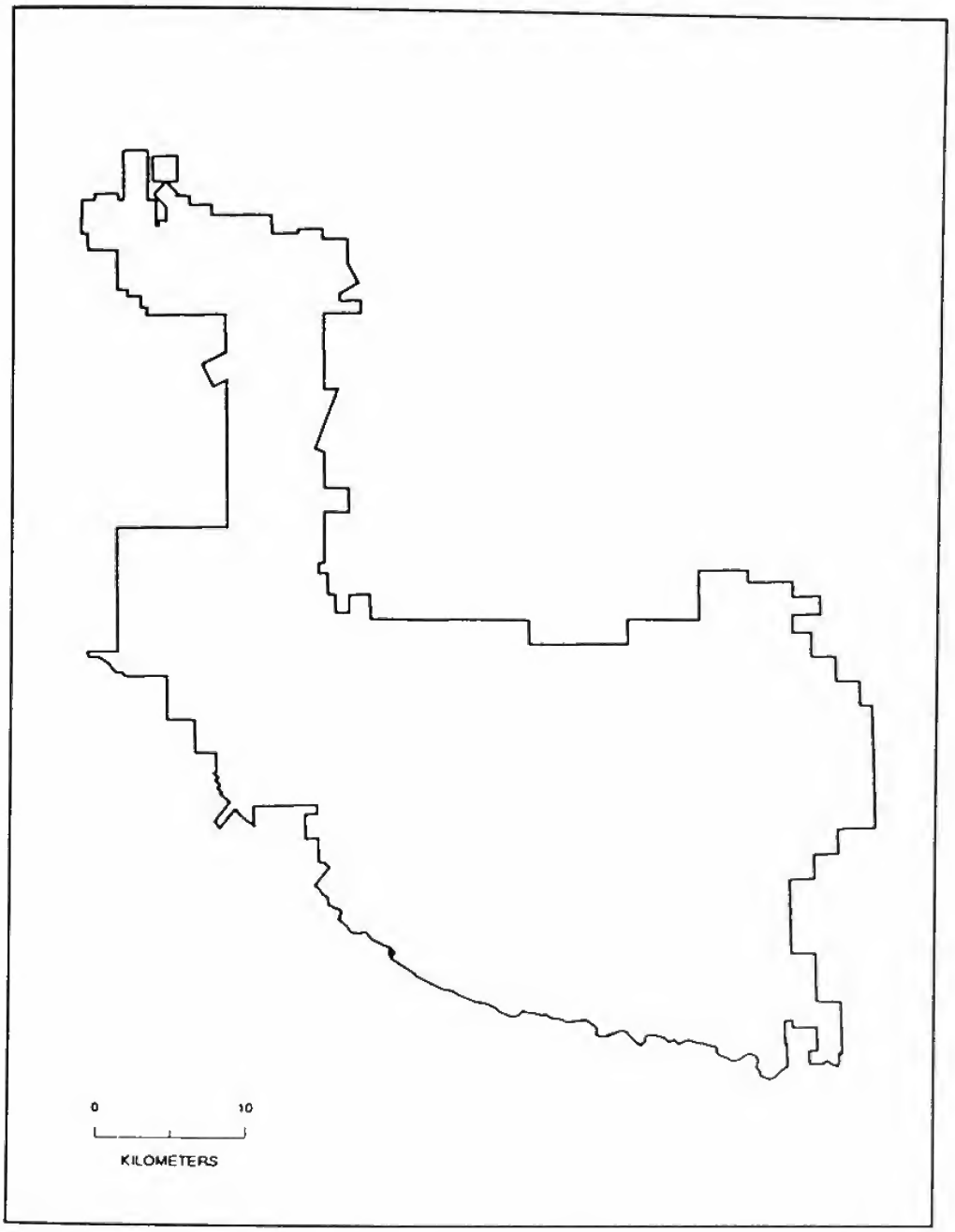

Figure 41. Localities of known specimens of *Peromyscus boylii* from Big Bend Ranch State Park, Texas.

Peromyscus eremicus (Baird, 1858)
Cactus Mouse

Description.— *Peromyscus eremicus* is a medium-sized mouse with an ochraceous buff dorsal pelage, but the head often is grayish. The tail is longer than the head and body, scantly haired, and not sharply bicolored, but the top may appear slightly darker than the bottom. The ears are short to intermediate in length. The ankles are dusky gray, and the soles of the hind feet are naked at the heels. The dental formula for *P. eremicus* is: i 1/1, c 0/0, p 0/0, m 3/3, total 16.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total

length, 184.7 (79, 165-201, 7.7); length of tail vertebrae, 96.5 (79, 86-115, 4.7); length of hind foot, 20.0 (84, 19-21, 0.5); length of ear from notch, 18.3 (84, 17-20, 0.7); weight, 18.0 (74, 13-24, 2.3); greatest length of skull, 25.01 (20, 23.60-26.42, 0.73). Females tend to be larger than males (Veal and Caire, 1979).

Of the other mammals at BBRSP, *P. eremicus* is mistaken most often for the other species of long-tailed *Peromyscus*. It can be differentiated from *P. boylii* as described in the account on that species. It can be distinguished from *P. pectoralis* on the basis of its naked, rather than haired heel; its dusky, rather than white ankles; and by having premaxillae that extend posteriorly well beyond the posterior ends of the nasals, rather than premaxillae that terminate at about the level of the nasals. In addition, the glans penis of male *P. eremicus* is vase-shaped, rather than elongate and rod-shaped, as in *P. pectoralis*. *P. eremicus* is distinguished from the other species of *Peromyscus* at BBRSP by having a tail that is longer than the head and body.

Distribution.— *P. eremicus* ranges from north-central Mexico, northward throughout the southwestern United States and Baja California (Veal and Caire, 1979). At BBRSP, this mouse is known from several localities throughout the park (Fig. 42).

Natural History.— With a relative abundance index of 0.922, *P. eremicus* was the third most frequently trapped rodent at BBRSP. It accounted for 13.9 percent of all rodents captured in the park. These figures indicate that the cactus mouse is abundant at BBRSP. Throughout the Trans-Pecos, this mouse has been reported as common at lower elevations and rare in montane areas (Schmidly, 1977*a*).

The cactus mouse is known to occur in several vegetation associations, including desert scrub, grassy areas, riparian habitat, and among juniper (Schmidly, 1977*a*; Veal and Caire, 1979). At BBRSP, this mouse was taken in each of these situations. Desert scrub and desert grassland were significantly favored over riparian areas ($P<0.001$ and $P=0.001$, respectively). There was no preference shown between the former two habitats ($P=0.587$). In comparison to juniper roughlands, capture rates for this species were higher in both desert scrub and grassland habitats, but lower in riparian habitat. But because of the small amount of juniper roughlands at BBRSP, a sample size adequate for statistical analyses was not obtained. *P. eremicus* has been reported as a soil generalist, inhabiting rocky, sandy, and loamy situations (Veal and Caire, 1979). At BBRSP, this mouse was taken from all three of these general substrata, but seemed to prefer rocky areas. *P. eremicus* also was taken commonly in association with man-made structures.

P. eremicus has been reported to estivate during summer as a means to conserve water and food (MacMillen, 1964; 1965). During this study, *P. eremicus* was taken during every month of the year, thus indicating that this mouse does not invariably enter prolonged summer torpor at BBRSP. However, trends in trap success of this mouse indicate that it is much less active during the summer months than other times of the year.

Davis and Schmidly (1994) reported the breeding season of *P. eremicus* to last at least from January through October, and possibly throughout the year. Two or more litters of one to four young are born per year. During this study, I examined 11 pregnant females carrying from one to three embryos (mean, 2.2) from early-February to late November. Pregnant females (with number of embryos and corresponding crown-rump lengths in parentheses) were examined on the following dates: 1 February (3 embryos, crown-rump length, 23), 5 February (1 embryo, crown-rump length, 17), 5 February (2 embryos, crown-rump length, 4), 28 February (2 embryos, crown-rump length, 6), 15 March (2 embryos, crown-rump length, 10), 2 April (2 embryos, crown-rump length, 18), 1 May (2 embryos, crown-rump length, 12), 4 May (3 embryos, crown-rump length, 23), 13 July (3 embryos, crown-rump length, 8), 9 November (2 embryos, crown-rump length, 5), and 28 November (2 embryos, crown-rump length, 4). Lactating females were examined on 1 and 26 February, 16 and 18 March, 1 and 2 May, 4 and 13 September, and 28 October. Juveniles were observed in the population on 1 February, 1, 4, 27, and 31 May, 3 July, 25 November, and 8 December. Subadults were noted on 1 February,

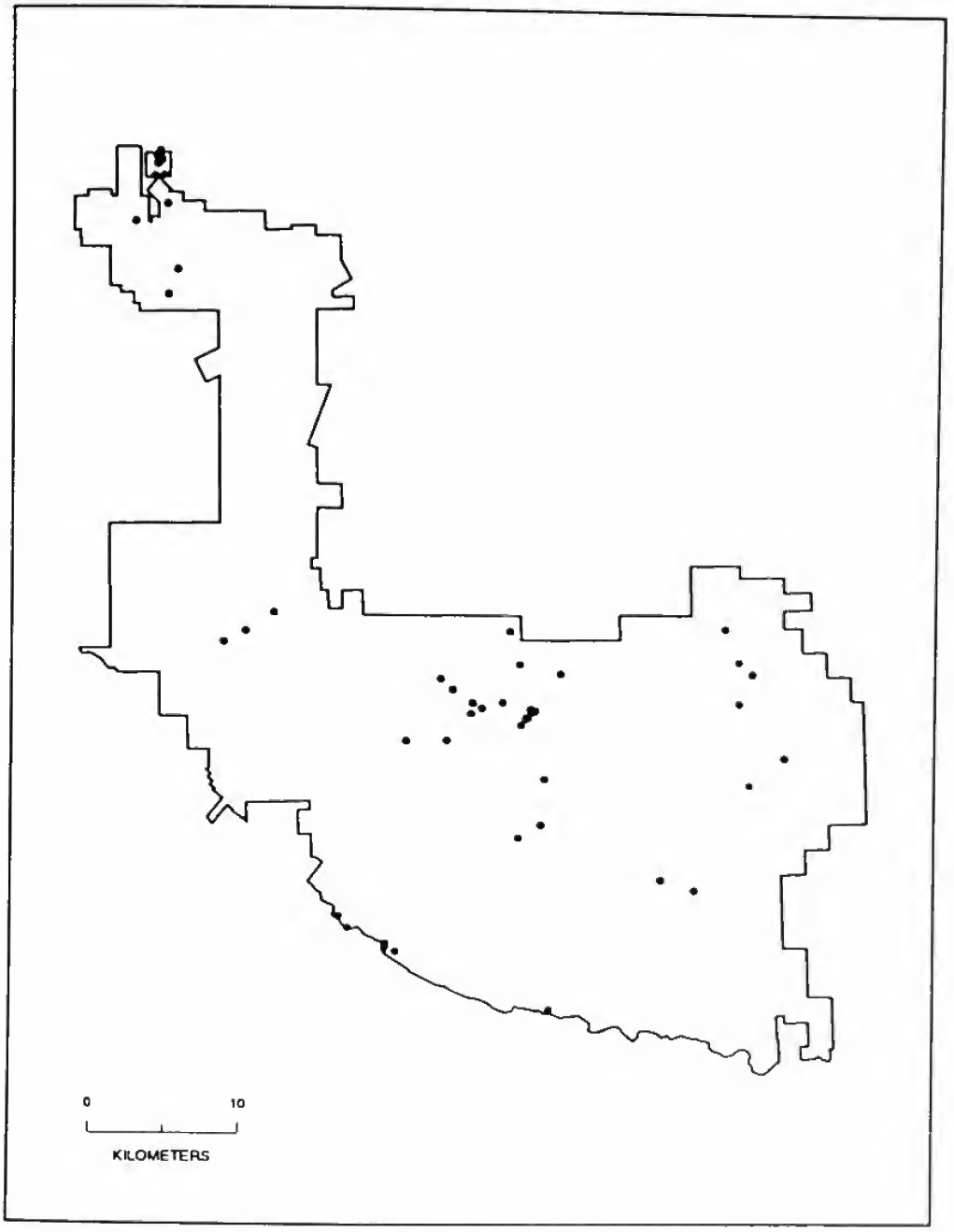

Figure 42. Localities of known specimens of *Peromyscus eremicus* from Big Bend Ranch State Park, Texas.

1, 2, and 26 May, 10 and 28 June, 13 and 18 July, 9 and 16 November, and 1, 2, 5, and 7 December. Testicular measurements of adult males ranged as follows: January, 6 X 3 to 7 X 4; February, 5 X 3 to 10 X 7; March, 10 X 6 to 11 X 6; May, 9 X 5 to 9 X 6; June, 10 X 6 to 12 X 5; July, 9 X 5; November, 4 X 2 to 12 X 6; December, 4 X 2 to 11 X 7. These data strongly support the notion of a year round breeding season at BBRSP.

P. eremicus is nocturnal and mostly feeds on the seeds of desert annuals. Other parts of plants, as well as insects, also are consumed (Veal and Caire, 1979). This mouse is scansorial to some extent, and has been known to forage up to two meters high in mesquite trees (Davis and Schmidly, 1994). Cactus mice apparently are prone to food hoarding (Barry, 1976).

Nothing previously has been reported regarding annual molt in *P. eremicus*. During this study, I examined adults in the process of molting during all months of the year, except April. These data suggest that *P. eremicus* may undergo two annual molts.

Other species of rodents taken at the same localities as *P. eremicus* at BBRSP included *Perognathus flavus*, *Chaetodipus eremicus*, *C. hispidus*, *C. intermedius*, *C. nelsoni*, *Dipodomys merriami*, *Reithrodontomys megalotis*, *Peromyscus leucopus*, *P. maniculatus*, *P. pectoralis*, *Onychomys arenicola*, *Neotoma albigula*, *N. mexicana*, and *N. micropus*.

Ectoparasites taken from *P. eremicus* at BBRSP include mites, ticks, and botfly larvae. Additional external parasites known from cactus mice are several species of fleas and lice. Endoparasites documented from *P. eremicus* include nematodes (Veal and Caire, 1979).

Comments.— The subspecies of *P. eremicus* at BBRSP is *P. e. eremicus* (Baird, 1858). See the account on *Peromyscus boylii* for the etymology of the generic name. The specific epithet *eremicus* is from the Greek "eremikos," meaning solitary (Stangl et al., 1993).

Specimens Examined (130).— Presidio Co.: BBRSP, UTM coordinates: 13 575323E 3292088N, 1; BBRSP, UTM coordinates: 13 576564E 3295022N, 2; BBRSP, UTM coordinates: 13 576721E 3296287N, 3; BBRSP, UTM coordinates: 13 576760E 3295806N, 1; BBRSP, UTM coordinates: 13 576808E 3295784N, 1; BBRSP, UTM coordinates: 13 576836E 3296251N, 2; BBRSP, UTM coordinates: 13 576842E 3296279N, 1; BBRSP, UTM coordinates: 13 576846E 3296245N, 2; BBRSP, UTM coordinates: 13 576931E 3296613N, 3; BBRSP, UTM coordinates: 13 576970E 3296222N, 3; BBRSP, UTM coordinates: 13 577066E 3296038N, 6; BBRSP, UTM coordinates: 13 577192E 3295041N, 1; BBRSP, UTM coordinates: 13 577436E 3293201N, 1; BBRSP, UTM coordinates: 13 577526E 3287386N, 1; BBRSP, UTM coordinates: 13 578146E 3288978N, 1; BBRSP, UTM coordinates: 13 581230E 3264998N, 1; BBRSP, UTM coordinates: 13 582656E 3265713N, 1; BBRSP, UTM coordinates: 13 584531E 3266930N, 1; BBRSP, UTM coordinates: 13 588746E 3247263N, 1; BBRSP, UTM coordinates: 13 589348E 3246503N, 11; BBRSP, UTM coordinates: 13 591851E 3245491N, 4; BBRSP, UTM coordinates: 13 592496E 3244969N, 4; BBRSP, UTM coordinates: 13 595478E 3262749N, 1; BBRSP, UTM coordinates: 13 595848E 3258744N, 3; BBRSP, UTM coordinates: 13 596255E 3262051N, 2; BBRSP, UTM coordinates: 13 597424E 3260494N, 8; BBRSP, UTM coordinates: 13 597543E 3261182N, 2; BBRSP, UTM coordinates: 13 598125E 3260852N, 1; BBRSP, UTM coordinates: 13 599495E 3261227N, 4; BBRSP, UTM coordinates: 13 599992E 3265848N, 2; BBRSP, UTM coordinates: 13 600515E 3252408N, 6; BBRSP, UTM coordinates: 13 600634E 3263701N, 1; BBRSP, UTM coordinates: 13 600694E 3259751N, 1; BBRSP, UTM coordinates: 13 601031E 3260217N, 6; BBRSP, UTM coordinates: 13 601059E 3260130N, 2; BBRSP, UTM coordinates: 13 601154E 3260197N, 2; BBRSP, UTM coordinates: 13 601335E 3260787N, 1; BBRSP, UTM coordinates: 13 601560E 3260590N, 3; BBRSP, UTM coordinates: 13 601622E 3260685N, 1; BBRSP, UTM coordinates: 13 601973E 3253265N, 1; BBRSP, UTM coordinates: 13 602211E 3256243N, 2; BBRSP, UTM coordinates: 13 602487E 3241236N, 1; BBRSP, UTM coordinates: 13 603273E 3263098N, 1; BBRSP, UTM coordinates: 13 614094E 3266037N, 2; BBRSP, UTM coordinates: 13 615033E 3263895N, 1; BBRSP, UTM coordinates: 13 615063E 3261184N, 1; BBRSP, UTM coordinates: 13 615747E 3255837N, 1; BBRSP, UTM coordinates: 13 615951E 3263099N, 1; BBRSP, UTM coordinates: 13 616012E 3263115N, 2; BBRSP, Colorado Canyon, 6 (SRSU); BBRSP, 0.75 mi. SW Aqua Adentro, 5 (SRSU); BBRSP, Chorro Canyon, 1 (SRSU); BBRSP, 15 mi. NW Lajitas, 4 (SRSU); BBRSP, Arroyo Primero, 1 (SRSU). Brewster Co.: BBRSP, UTM coordinates: 13 618185E 3257611N, 2.

Peromyscus leucopus (Rafinesque, 1818)
White-footed Mouse

Description.— *Peromyscus leucopus* is a medium-sized mouse with a pale brown dorsal pelage that often is mixed with grayish. The tail of this mouse is relatively short (shorter than head and body), lightly haired, and indistinctly bicolored, and its ears are short. The dental formula for *P. leucopus* is: i 1/1, c 0/0, p 0/0, m 3/3, total 16.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 175.4 (46 160-190, 7.6); length of tail vertebrae, 80.6 (46, 71-91, 4.8); length of hind foot, 21.6 (47, 21-23, 0.6); length of ear from notch, 16.9 (47, 15-19, 0.7); weight, 21.2 (41, 17-26, 2.3); greatest length of skull, 26.83 (20, 25.42-27.88, 0.60). I know of no documentation of significant secondary sexual dimorphism in *P. leucopus*.

At BBRSP, *P. leucopus* is distinguished from *P. maniculatus* only with great difficulty. Typically, the tail of *P. leucopus* is bicolored, but not distinctly so, whereas it usually is distinctly bicolored in *P. maniculatus*. In addition, *P. leucopus* typically has a larger total length (mean, 175.4) and a longer tail (mean, 80.6), and greater length of skull (mean, 26.83), than those of *P. maniculatus* (means, 159.3, 73.5, and 25.61, respectively). *P. leucopus* is distinguished easily from other *Peromyscus* at BBRSP by having a tail that is shorter than its head and body.

Distribution.— *P. leucopus* ranges from eastern and north-central Mexico, northward throughout the eastern two thirds of the United States and parts of southern Canada (Carleton, 1989). At BBRSP, *P. leucopus* is known from scattered localities throughout the park (Fig. 43).

Natural History.— *P. leucopus* was found to have a relative abundance index of 0.574. It accounted for 8.7 percent of all rodents trapped at BBRSP, and ranked eighth among rodents. These figures, which suggest that *P. leucopus* is neither abundant nor rare at BBRSP, are somewhat misleading. This mouse was found to be fairly abundant in areas of suitable habitat and rare or absent from unpreferred habitat.

Schmidly (1977*a*) reported *P. leucopus* as common in riparian woodlands, and lacking from desert situations in the Trans-Pecos region. At BBRSP, I collected white-footed mice from riparian woodland, as well as from desert scrub and desert grassland. This mouse did, in fact, show a significant preference for riparian woodland over both desert scrub ($P<0.001$) and desert grassland ($P<0.001$). Moreover, it was the most frequently trapped rodent in riparian woodland. There was no significant difference noted between desert scrub and desert grassland affinities ($P=0.024$).

P. leucopus is known to be active throughout the year (Jones et al., 1985). At BBRSP this mouse was taken during every month of the year.

In some parts of its range, *P. leucopus* is known to breed throughout the year (Choate et al., 1994; Davis and Schmidly, 1994), whereas at other places it reproduces only during the warmer months (Jones et al., 1985). Gravid females previously have been recorded from the Trans-Pecos only during March, April, June, and August (Schmidly, 1977*a*). At BBRSP, I examined 7 pregnant females carrying from three to four embryos (mean, 3.7) on the following dates (with number of embryos and corresponding crown-rump lengths in parentheses): 9 January (4 embryos, crown-rump length, 17), 18 March (4 embryos, crown-rump length, 2), 1 April (3 embryos, crown-rump length, 16), 7 July (4 embryos, crown-rump length, 11; 4 embryos, crown-rump length, 15), 8 July (3 embryos, crown-rump length, 9), and 10 December (4 embryos, crown-rump length, 6). A lactating female was noted on 27 July. Juveniles were observed in the population on 9 January, 3 and 4 April, 7 July, and 13 and 18 September. Subadults were taken on 15 March, 2 April, 17, 18, and 27 July, 24 August, 19 September, 13 October, 27 November, and 8 and 10 December. Testicular measurements of adult males ranged as follows: January, 8 X 5 to 13 X 8; February, 10 X 5; March, 6 X 4 to 20 X 10; April, 10 X 4 to 20 X 10; July, 13 X 7; September, 13 X 7, November, 10 X 6; December, 9 X 5. These data indicate that *P. leucopus* breeds year round at BBRSP, and that females probably bear multiple litters each year.

P. leucopus mostly is nocturnal, at which time it forages primarily for seeds, mesquite beans, berries, fruits, nuts, and insects (Schmidly, 1977*a*; Jones et al., 1985). In addition, carrion sometimes is consumed. A considerable amount of the foraging activities of the white-footed mouse occurs in brushy vegetation (Jones et al., 1985).

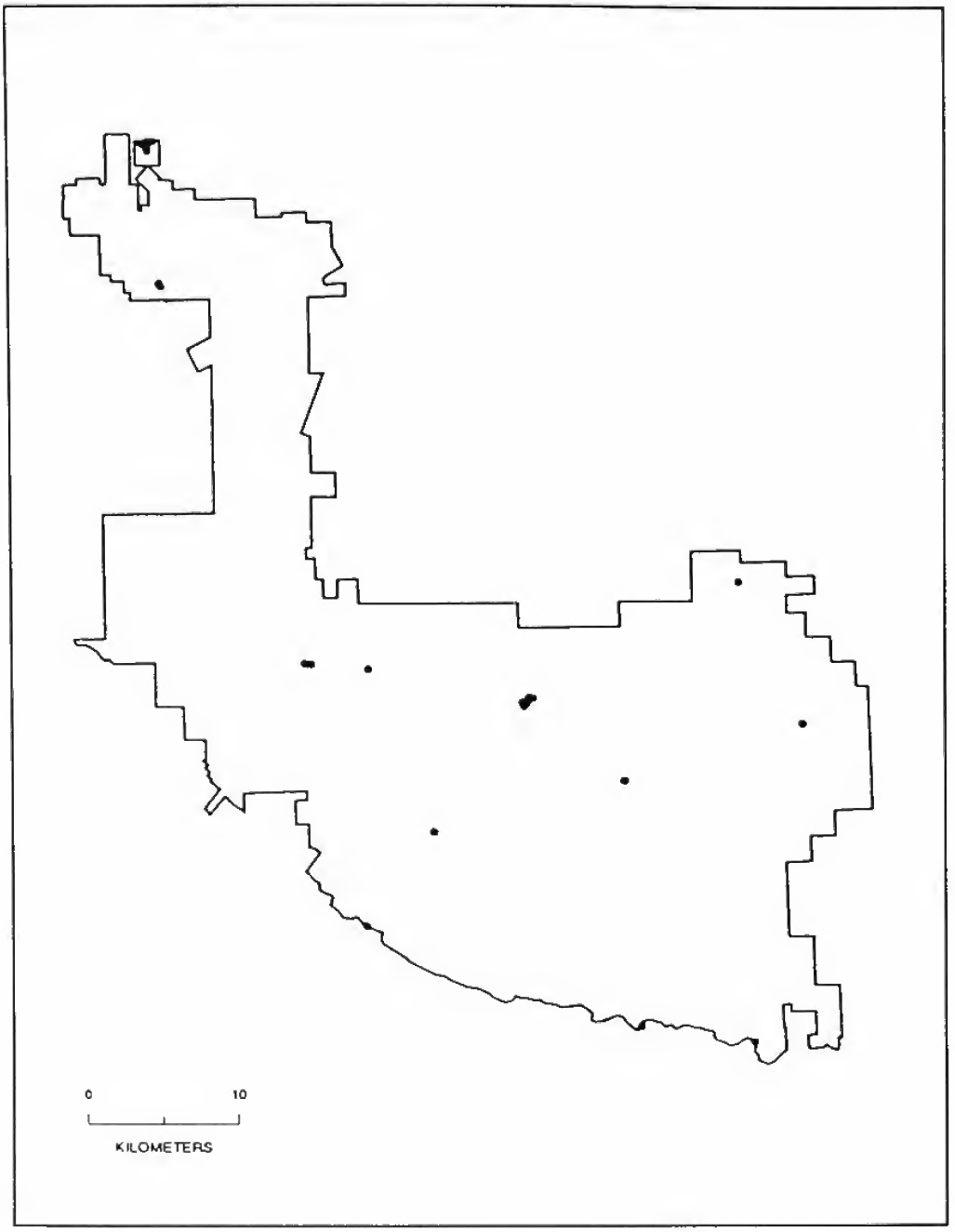

Figure 43. Localities of known specimens of *Peromyscus leucopus* from Big Bend Ranch State Park, Texas.

Adult white-footed mice reportedly undergo a single annual molt beginning in spring or early summer (Choate et al., 1994). I examined molting adults during January, July, and November. This suggests that at BBRSP, *P. leucopus* may molt twice a year or at various times during the year.

Other species of rodents taken at the same localities as *P. leucopus* at BBRSP included *Perognathus flavus*, *Chaetodipus eremicus*, *C. hispidus*, *C. nelsoni*, *Dipodomys merriami*, *Reithrodontomys fulvescens*, *R. megalotis*, *Peromyscus eremicus*, *P. maniculatus*, *P. pectoralis*, *Sigmodon hispidus*, and *S. ochrognathus*.

Fleas were the only parasites noted in association with specimens of *P. leucopus* from BBRSP. Additional external parasites known from white-footed mice include mites, ticks, lice, and botfly larvae. Endoparasites known from *P. leucopus* include trematodes, cestodes, and nematodes (Whitaker, 1968). The white-footed mouse has been implicated as the primary reservoir for the bacterium *Borrelia burgdorferi*, the etiologic agent of Lyme disease (Benach et al., 1990).

Comments.— The subspecies of *P. leucopus* at BBRSP is *P. l. tornillo* Mearns, 1896. See the account on *Peromyscus boylii* for the etymology of the generic name. The specific epithet *leucopus* is from the Greek "leukos" and "pous," meaning white and foot, respectively (Stangl et al., 1993).

Specimens Examined (69).— Presidio Co.: BBRSP, UTM coordinates: 13 576390E 3296223N, 1; BBRSP, UTM coordinates: 13 576708E 3296384N, 1; BBRSP, UTM coordinates: 13 576760E 3295806N, 2; BBRSP, UTM coordinates: 13 576785E 3296105N, 2; BBRSP, UTM coordinates: 13 576790E 3296211N, 2; BBRSP, UTM coordinates: 13 576804E 3296151N, 5; BBRSP, UTM coordinates: 13 576836E 3296251N, 8; BBRSP, UTM coordinates: 13 576842E 3296279N, 1; BBRSP, UTM coordinates: 13 576846E 3296245N, 1; BBRSP, UTM coordinates: 13 577099E 3296389N, 1; BBRSP, UTM coordinates: 13 577472E 3287353N, 1; BBRSP, UTM coordinates: 13 577589E 3287154N, 4; BBRSP, UTM coordinates: 13 586809E 3262961N, 2; BBRSP, UTM coordinates: 13 586937E 3262923N, 4; BBRSP, UTM coordinates: 13 587250E 3262918N, 5; BBRSP, UTM coordinates: 13 590728E 3245948N, 2; BBRSP, UTM coordinates: 13 590980E 3262597N, 5; BBRSP, UTM coordinates: 13 595150E 3252057N, 3; BBRSP, UTM coordinates: 13 600914E 3260458N, 2; BBRSP, UTM coordinates: 13 601031E 3260217N, 2; BBRSP, UTM coordinates: 13 601221E 3260400N, 1; BBRSP, UTM coordinates: 13 601335E 3260787N, 1; BBRSP, UTM coordinates: 13 601619E 3260741N, 3; BBRSP, UTM coordinates: 13 607355E 3255359N, 1; BBRSP, UTM coordinates: 13 608309E 3239482N, 4; BBRSP, UTM coordinates: 13 614935E 3268144N, 2; BBRSP, UTM coordinates: 13 615800E 3238476N, 2. Brewster Co.: BBRSP, UTM coordinates: 13 619125E 3258986N, 1.

Peromyscus maniculatus (Wagner, 1845)
Deer Mouse

Description.— *Peromyscus maniculatus* is a small to medium-sized mouse with a dorsal pelage that ranges from pale ochraceous to dull gray in color. The tail is short (decidedly shorter than head and body), scantly haired, and distinctly bicolored, and its ears are short. The dental formula for *P. maniculatus* is: i 1/1, c 0/0, p 0/0, m 3/3, total 16.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 159.3 (47, 144-171, 7.0); length of tail vertebrae, 73.5 (47, 65-79, 3.4); length of hind foot, 21.2 (47, 20-23, 0.6); length of ear from notch, 16.9 (47, 16-19, 0.8); weight, 17.8 (45, 14-25, 2.8); greatest length of skull, 25.61 (20, 24.04-27.85, 0.81). I know of no reports of significant secondary sexual dimorphism in *P. maniculatus*.

At BBRSP, *P. maniculatus* is confused most easily with *P. leucopus*. See the previous account for differentiating characters. *P. maniculatus* is distinguished easily from other species of *Peromyscus* at BBRSP by having a tail that is shorter than its head and body.

Distribution.— The range of *P. maniculatus* extends from southern Mexico, northward throughout central Mexico, thence throughout most of the United States and Canada (Carlton, 1989). At BBRSP, the deer mouse is known from scattered localities throughout the park (Fig. 44).

Natural History.— With a relative abundance index of 0.477, *P. maniculatus* accounted for 7.2 percent of all rodents trapped at BBRSP. Based on these figures, deer mice apparently occur at BBRSP in moderate numbers, being neither extremely abundant nor uncommon.

Throughout the Trans-Pecos, *P. maniculatus* is reported as partial to desert scrub and grasslands, and

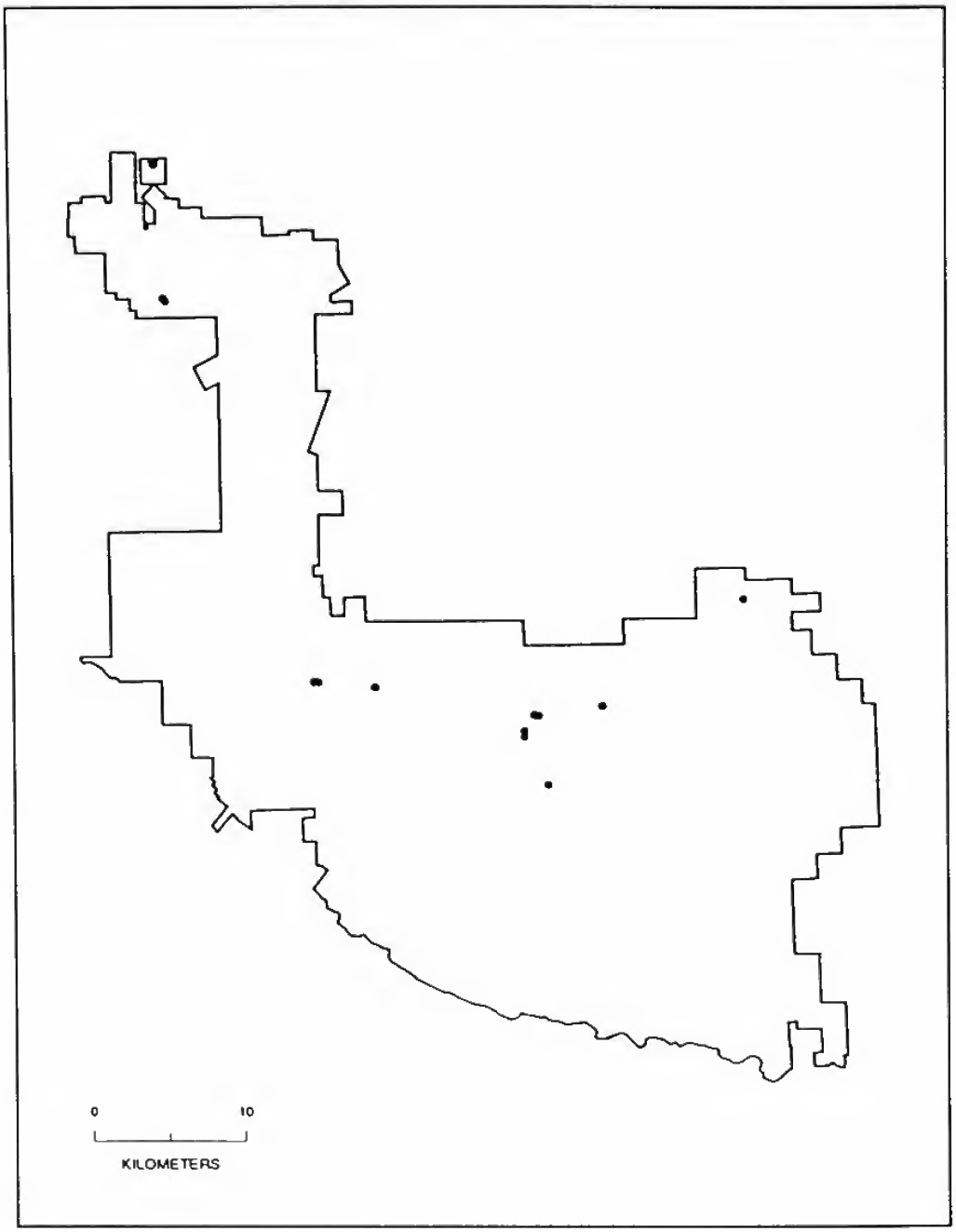

Figure 44. Localities of known specimens of *Peromyscus maniculatus* from Big Bend Ranch State Park, Texas.

rare in woodlands (Schmidly, 1977*a*). During this study, this mouse was taken in all three of these habitats. It showed a significant preference for riparian woodland over both desert scrub ($P<0.001$) and desert grassland ($P<0.001$). Grassland was second in order of habitat preference, as the capture rate of *P. maniculatus* in this habitat was significantly higher than that in desert scrub ($P=0.015$).

P. maniculatus is not known to hibernate (Davis and Schmidly, 1994). During this study, deer mice were taken during each season of the year, confirming that they are active year round at BBRSP.

The breeding season of *P. maniculatus* is known to extend throughout the year (Davis and Schmidly,

1994). Multiple litters of about four young are produced annually (Schmidly, 1977*a*; Millar, 1989). At BBRSP, I examined two pregnant females, one carrying four embryos (crown-rump length, 2) and the other with two embryos (crown-rump length, 10) on 27 May and 30 November, respectively. Juveniles were observed in the population on 1 April and 10 November. Subadults were noted on 27 February, 5 July, and 10 and 30 November. Testicular measurements of adult males ranged as follows: January, 6 X 3; February, 6 X 3 to 14 X 8; March, 3 X 2 to 5 X 3; April, 9 X 4 to 15 X 4; September, 10 X 6, November, 3 X 2 to 7 X 3.

P. maniculatus primarily is nocturnal, foraging primarily for seeds. In addition, grains, fruits, bark, roots, green vegetation, and insects may be consumed (Schmidly, 1977*a*; Davis and Schmidly, 1994). This mouse occasionally may climb vegetation in an attempt to gather food (Davis and Schmidly, 1994).

Little is known regarding annual molting in *P. maniculatus*. During this study, molting adults were examined during February, March, May, September, and November. These data suggest two possible seasonal molts; one during spring (or late winter), the other in autumn.

Other species of rodents taken at the same localities as *P. maniculatus* at BBRSP included *Thomomys bottae*, *Cratogeomys castanops*, *Perognathus flavus*, *Chaetodipus eremicus*, *C. hispidus*, *Dipodomys merriami*, *Reithrodontomys fulvescens*, *R. megalotis*, *Peromyscus eremicus*, *P. leucopus*, *P. pectoralis*, *Onychomys arenicola*, *Sigmodon hispidus*, *S. ochrognathus*, and *Neotoma Micropus*.

Fleas and ticks were the only parasites found in association with specimens of *P. maniculatus* from BBRSP. Additional ectoparasites known from white-footed mice include mites, lice, and botfly larvae. Endoparasites known to infect *P. maniculatus* include several species of trematodes, cestodes, and nematodes (Whitaker, 1968). The deer mouse has been implicated as the primary reservoir for Sin Nombre virus, a strain of hantavirus responsible for hantavirus pulmonary syndrome (Hughes et al., 1990; Mills et al., 1995).

Comments.— The subspecies of *P. maniculatus* at BBRSP is *P. m. blandus* Osgood, 1904. See the account on *Peromyscus boylii* for the etymology of the generic name. The specific epithet *maniculatus* is from the Latin "manicula," meaning small hand (Stangl et al., 1993).

Specimens Examined (57).— Presidio Co.: BBRSP, UTM coordinates: 13 576699E 3296276N, 1; BBRSP, UTM coordinates: 13 576757E 3296109N, 1; BBRSP, UTM coordinates: 13 576785E 3296105N, 3; BBRSP, UTM coordinates: 13 576836E 3296251N, 5; BBRSP, UTM coordinates: 13 577321E 3287548N, 3; BBRSP, UTM coordinates: 13 577472E 3287353N, 3; BBRSP, UTM coordinates: 13 586937E 3262923N, 3; BBRSP, UTM coordinates: 13 587250E 3262918N, 6; BBRSP, UTM coordinates: 13 590980E 3262597N, 12; BBRSP, UTM coordinates: 13 600684E 3259365N, 2; BBRSP, UTM coordinates: 13 600694E 3259751N, 2; BBRSP, UTM coordinates: 13 601335E 3260787N, 1; BBRSP, UTM coordinates: 13 601619E 3260741N, 4; BBRSP, UTM coordinates: 13 602211E 3256243N, 2; BBRSP, UTM coordinates: 13 605746E 3261330N, 4; BBRSP, UTM coordinates: 13 614935E 3268144N, 5.

Peromyscus pectoralis Osgood, 1904
White-ankled Mouse

Description.— *Peromyscus pectoralis* is a medium-sized mouse with a grayish brown dorsal pelage that is washed with black. The tail is longer than the head and body, scantly haired, and not sharply bicolored. The ears are short. The ankles are white, and the soles of the hind feet are haired at the heels. The dental formula for *P. pectoralis* is: i 1/1, c 0/0, p 0/0, m 3/3, total 16.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 191.5 (35, 168-223, 11.2); length of tail vertebrae, 102.5 (35, 91-114, 6.3); length of hind foot, 21.2 (37, 20-22, 0.7); length of ear from notch, 17.6 (37,

17-19, 0.6); weight, 17.2 (35, 13-21, 2.2); greatest length of skull, 26.84 (20, 25.83-27.84, 0.68). Overall, males and females are approximately the same size (Schmidly, 1972).

At BBRSP, *P. pectoralis* is mistaken most often for *P. boylii* and *P. eremicus*. See the accounts of these species for differentiation.

Distribution.— The range of *P. pectoralis* extends from central Mexico, northward to the United States, where it occurs in southwestern New Mexico, southwestern and central Texas, an southern Oklahoma (Schmidly, 1974). At BBRSP, *P. pectoralis* is known from scattered localities throughout the southern part of the park (Fig. 45).

Natural History.— At BBRSP, *P. pectoralis* was found to have a relative abundance index of 0.453. This species comprised 6.8 percent of all rodents trapped. White-ankled mice apparently are common, yet not overwhelmingly abundant at BBRSP.

P. pectoralis has been reported to inhabit a variety of vegetational conditions, including desert scrub, grassland, and juniper woodland (Blair, 1940; Schmidly, 1974; 1977*a*). During this study, *P. pectoralis* was taken in all four major habitat types, albeit not in equal numbers ($P<0.001$). Interestingly, this mouse was more common in riparian woodland than either desert scrub or grassland ($P<0.001$ and $P=0.001$, respectively). It was found to favor desert grassland over desert scrub ($P=0.001$). The greatest capture rate for this species was in juniper roughlands, but due to the small amount of this habitat in the park, sample sizes were insufficient for statistical comparisons. All individuals encountered were in or near rocky areas. *P. pectoralis* is a saxicolous mouse (Schmidly, 1974); the presence of rocks, rather than vegetation type, seems to be the primary requirement for suitable habitat.

During this study, white-ankled mice were taken during each season of the year, thus indicating that this species is active throughout the year at BBRSP.

Little is known regarding the reproductive biology of *P. pectoralis* in the Trans-Pecos. Pregnant females from this area are known from March, April, July, and August (Schmidly, 1977*a*). In nearby Coahuila, Mexico, gravid females were taken during March, April, May, June, September, October, and December (Baker, 1956). At BBRSP, I examined two pregnant females, one carrying four embryos (crown-rump length, 19) and the other with two embryos (crown-rump length, 10) on 13 and 14 March, respectively. Juveniles were observed in the population on 10 January and 8 November. Subadults were noted on 10 January, 24, 26, and 28 February, 8 November, and 1 December. Testicular measurements of adult males ranged as follows: January, 4 X 2 to 9 X 5; February, 3 X 2 to 12 X 7; March, 3 X 2 to 11 X 5; July, 9 X 6; November, 9 X 6, December, 3 X 2 to 10 X 5. The data from this study, along with those of Baker (1956) and Schmidly (1977*a*) collectively suggest that *P. pectoralis* breeds throughout the year, and that two or more litters may be produced. Litter sizes are known to range from two to seven (Schmidly, 1974).

P. pectoralis is nocturnal, at which time it forages primarily for seeds, juniper berries, acorns, cactus fruits, and hackberries. Other fruits and insects probably are eaten as well (Schmidly, 1974; Davis and Schmidly, 1994).

Little is known about the annual molting process in *P. pectoralis*. During this study, molting adults were examined during February, May, July, November, and December. These data suggest that either a single molt occurs at various times, or that this mouse possibly exhibits two seasonal molts.

Other species of rodents taken at the same localities as *P. pectoralis* at BBRSP included *Chaetodipus eremicus*, *C. nelsoni*, *Dipodomys merriami*, *Reithrodontomys fulvescens*, *R. megalotis*, *Peromyscus eremicus*, *P. leucopus*, *P. maniculatus*, *Sigmodon hispidus*, and *Neotoma albigula*.

Ectoparasites observed infesting *P. pectoralis* specimens from BBRSP included mites and fleas. An unidentified tapeworm was collected from the gut of a white-ankled mouse from BBRSP.

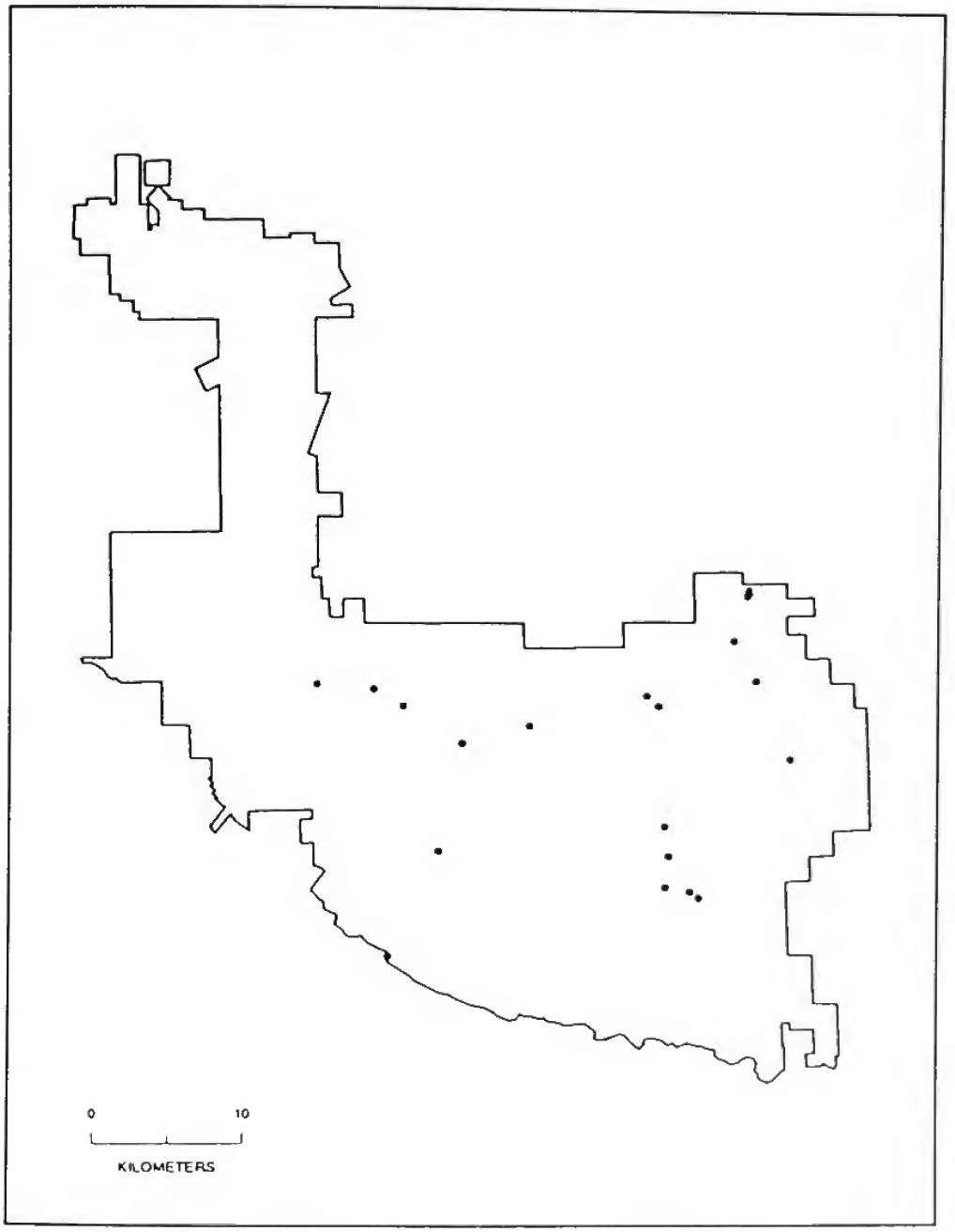

Figure 45. Localities of known specimens of *Peromyscus pectoralis* from Big Bend Ranch State Park, Texas.

Comments.— The subspecies of *P. pectoralis* at BBRSP is *P. p. laceianus* Bailey, 1906. See the account on *Peromyscus boylii* for the etymology of the generic name. The specific epithet *pectoralis* is Latin for of the breast (Stangl et al., 1993).

Specimens Examined (67).— Presidio Co.: BBRSP, UTM coordinates: 13 587250E 3262918N, 6; BBRSP, UTM coordinates: 13 590980E 3262597N, 4; BBRSP, UTM coordinates: 13 592898E 3261518N, 1; BBRSP, UTM coordinates: 13 596699E 3259093N, 3; BBRSP, UTM coordinates: 13 601031E 3260217N, 1; BBRSP, UTM coordinates: 13 608629E 3262171N, 3; BBRSP, UTM coordinates: 13 609405E 3261495N, 1; BBRSP, UTM coordinates: 13 609770E 3253645N, 2; BBRSP, UTM coordinates: 13 611393E 3249399N, 2; BBRSP, UTM coordinates: 13 614458E 3265716N,

10; BBRSP, UTM coordinates: 13 615409E 3268594N, 1; BBRSP, UTM coordinates: 13 615525E 3268958N, 5; BBRSP, UTM coordinates: 13 615559E 3268762N, 9; BBRSP, UTM coordinates: 13 615951E 3263099N, 4; BBRSP, UTM coordinates: 13 616012E 3263115N, 1; BBRSP, Ojito Adentro, 2 (SRSU); BBRSP, Colorado Canyon, 1 (SRSU); BBRSP, Rancherias Springs, 1 (SRSU); BBRSP, 15 mi. NW Lajitas, 1 (SRSU); BBRSP, Chorro Canyon, 5 (SRSU); BBRSP, Smith Ranch, Fresno Canyon, 1 (SRSU); BBRSP, 15 mi. N Lajitas, 1 (SRSU). Brewster Co.: BBRSP, UTM coordinates: 13 618322E 3258007N, 2.

Onychomys arenicola Mearns, 1896
Mearns' Grasshopper Mouse

Description.— *Onychomys arenicola* is a medium-sized mouse with a pale brown to buffy gray dorsal pelage. The tail is short (less than 60 percent of head and body length), lightly haired, indistinctly bicolored, and often tipped in white. The ears are short, and each has a whitish gray patch at the anterior base. The dental formula for *O. arenicola* is: i 1/1, c 0/0, p 0/0, m 3/3, total 16.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 146.9 (9, 129-156, 8.4); length of tail vertebrae, 54.1 (9, 48-60, 4.7); length of hind foot, 20.7 (9, 19-22, 0.9); length of ear from notch, 17.1 (9, 17-18, 0.3); weight, 18.7 (9, 15-22, 2.0); greatest length of skull, 25.60 (7, 25.25-26.21, 0.32). I know of no reports of sexual dimorphism in *O. arenicola*.

O. arenicola possibly could be confused with members of the genus *Peromyscus*, but can be identified easily by the short tail. In addition, the coronoid process extends well above the condyloid process, which it does not in members of the genus *Peromyscus*.

Distribution.— *O. arenicola* ranges from central Mexico, northward to the United States where it occurs in southeastern Arizona, southern New Mexico, and West Texas (Musser and Carlton, 1993). At BBRSP, this mouse is known from the Cienega Mountains, the Sauceda area, various sites in the Bofecillos Mountains, and the north rim of the Solitario (Fig. 46).

Natural History.— During this study, *O. arenicola* was found to have a relative abundance index of 0.081. It accounted for 1.2 percent of rodents trapped at BBRSP. Based on these figures, *O. arenicola* should be regarded as uncommon at the park. Schmidly (1977*a*) reported this mouse as extremely rare in the Big Bend Region.

O. arenicola has been reported to favor lowland desert scrub. At BBRSP, it was found in this type of habitat, but also in upland desert grassland and juniper woodland habitats. There was no significant difference detected between capture rates in desert scrub and grassland (P=0.677). The capture rate in juniper roughlands was the highest of all habitats for this species, but due to the small amount of this habitat in the park, sample sizes were insufficient for statistical comparisons. This grasshopper mouse was taken on sandy, gravelly, and rocky substrata.

During this study, Mearns' grasshopper mouse was taken in the months of February, April, May, June, and November. In Big Bend National Park, this mouse was trapped during March, May, July, August, September, and November (Jones et al., 1993). These data indicate that *O. arenicola* is active year round in the Big Bend region.

The breeding period of *O. arenicola* reportedly extends from late January or early February to September. Females give birth to litters of two to seven (mean, 4.2) young, two or three times a year (Davis and Schmidly, 1994). During this study, a subadult individual was observed on 31 May. Adult males had testes that measured as follows: February, 8 X 5 and 12 X 7; April, 15 X 9; June, 14 X 8; November, 6 X 3.

O. arenicola is active at night during which time it forages mostly for insects. Additional food items include other arthropods, especially scorpions, and small

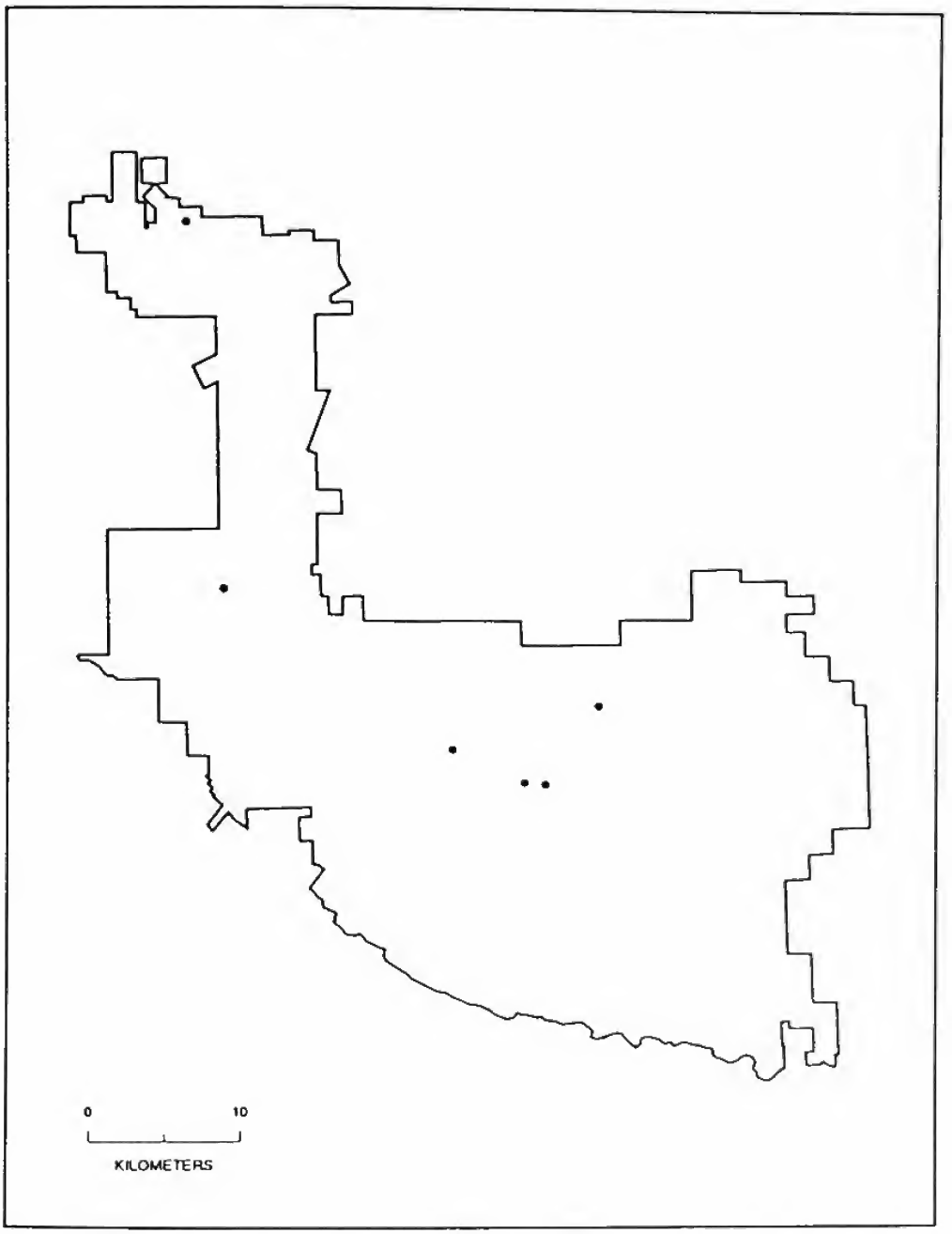

Figure 46. Localities of known specimens of *Onychomys arenicola* from Big Bend Ranch State Park, Texas.

mammals (Genoways et al., 1979). At BBRSP, a captive Mearns' grasshopper mouse that was presented with a small scorpion (*Centruroides* sp.) consumed the entire arthropod within minutes, and I have witnessed a grasshopper mouse killing and feeding on a medium-sized kangaroo rat. In addition to animal matter, a small amount of plant material also may be consumed (Davis and Schmidly, 1994).

Little is known about patterns of annual molt in *O. arenicola*. I examined molting adults from BBRSP during February and November.

Other species of rodents taken at the same localities as *O. arenicola* at BBRSP included *Perognathus flavus*, *Dipodomys merriami*, *Reithrodontomys*

megalotis, *Peromyscus eremicus*, and *P. maniculatus*. *O. arenicola* often is found in association with *D. merriami* (Schmidly, 1977*a*). During this study, *D. merriami* was taken at four of the seven traplines from which *O. arenicola* was captured.

Little is known of the parasites harbored by *O. arenicola*. At BBRSP, ectoparasites found on this mouse were mites and fleas. An undetermined species of nematode was the only endoparasite noted.

Comments.— The subspecies of *O. arenicola* at BBRSP is *O. a. arenicola* Mearns, 1896. The generic name *Onychomys* is derived from the Greek "onyx" and "mys," which translate to claw, and mouse, respectively. The specific epithet *arenicola* is from the Latin "harena" and "colere," meaning sand, and inhabit, respectively (Stangl et al., 1993). Individuals of this species in the Big Bend area previously were referred to as *O. torridus* (Schmidly, 1977*a*). However, subsequent examination of morphologic and chromosomal data indicated these mice to be a separate species (Hinesley, 1979).

Specimens Examined (10).— Presidio Co.: BBRSP, UTM coordinates: 13 578883E 3292424N, 1; BBRSP, UTM coordinates: 13 581288E 3268847N, 2; BBRSP, UTM coordinates: 13 596232E 3258492N, 1; BBRSP, UTM coordinates: 13 600868E 3256344N, 1; BBRSP, UTM coordinates: 13 602211E 3256243N, 1; BBRSP, UTM coordinates: 13 605746E 3261330N, 1; BBRSP, UTM coordinates: 13 615033E 3263895N, 3.

Sigmodon hispidus Say and Ord, 1825
Hispid Cotton Rat

Description.— *Sigmodon hispidus* is a large rat with a dorsal pelage formed of coarse, black, guard hairs tipped with golden brown, thus appearing grizzled brown in color. The tail is relatively short, sparsely haired, and scaly. The ears are short. The dental formula for *S. hispidus* is: i 1/1, c 0/0, p 0/0, m 3/3, total 16.

The total length and length of tail vertebrae measurements of a single specimen from BBRSP are 276 and 111, respectively. Means of the other standard external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: length of hind foot, 31.7 (3, 29-34, 2.5); length of ear from notch, 19.3 (3, 19-20, 0.6); weight, 95.7 (3, 77-114, 18.5); greatest length of skull, 34.77 (3, 34.67-34.89, 0.11). Males are slightly larger than females (Cameron and Spencer, 1981).

S. ochrognathus is the only mammal at BBRSP for which *S. hispidus* might be mistaken. However, *S. hispidus* is identified easily by the lack of a yellow-orange nose, which is present and obvious in *S. ochrognathus*.

Distribution.— *S. hispidus* ranges from northern South America, northward throughout Central America and Mexico and into the south-central and southeastern United States. An isolated population occurs in southwestern Arizona, southeastern California, and western Mexico (Cameron and Spencer, 1981). At BBRSP, *S. hispidus* is known from Las Quevas and Rancherias Springs (Fig. 47).

Natural History.— With a relative abundance index of 0.032, *S. hispidus* accounted for 0.5 percent of the rodents trapped at BBRSP. That this rat was found to be rare in the park was somewhat of a surprise, as in nearby areas of Big Bend National Park, *S. hispidus* was reported as common (Jones et al., 1993). Population sizes of this species are known to decline in response to drought conditions such as those encountered during this study. Numbers reportedly increase in response to the return of normal precipitation levels (Schmidly, 1977*a*).

S. hispidus reportedly prefers grassy situations, especially those near sources of water (Cameron and Spencer, 1981; Jones et al., 1993). However, this cotton rat also may inhabit creosote scrub (Jones et al., 1993). At BBRSP, *S. hispidus* was taken only in dense riparian woodland with thick grass.

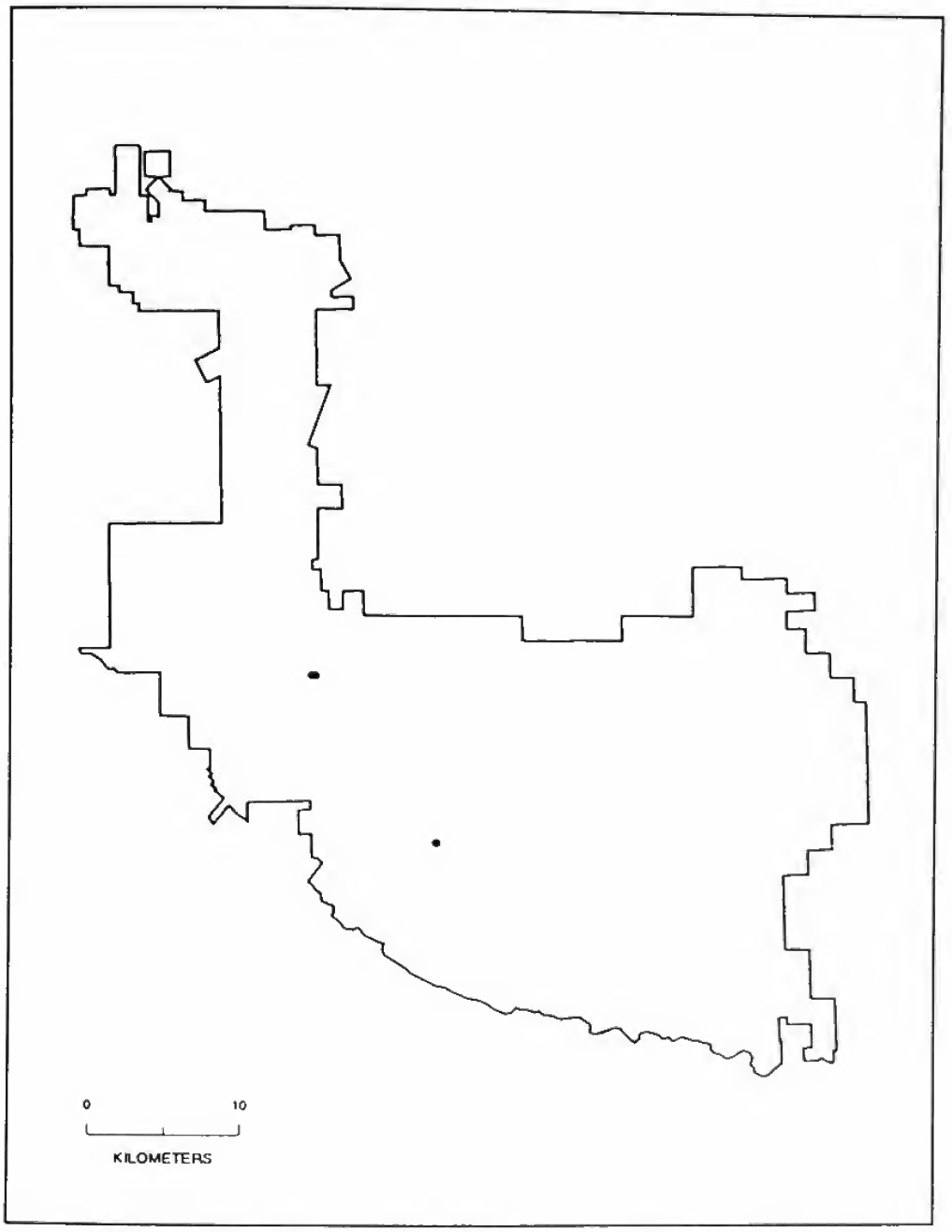

Figure 47. Localities of known specimens of *Sigmodon hispidus* from Big Bend Ranch State Park, Texas.

During this study, *S. hispidus* was acquired in May, July, and November; however, this rat is active year round throughout its range (Cameron and Spencer, 1981).

The breeding habits of *S. hispidus* apparently vary in response to levels of precipitation. During wet years, this rat breeds throughout the year, whereas during periods of drought, reproductive activity declines significantly (Schmidly, 1977*a*). Litter sizes for hispid cotton rats range from one to 15, but are known to vary geographically (Cameron and Spencer, 1981). I did not observe any gravid females from BBRSP; however, three pregnant females from Big Bend National Park carried from six to eight embryos (mean, 7; Jones et al.,

1993). I examined a lactating female on 10 November, and an adult male with testes measuring 18 X 10 on 7 July.

S. hispidus primarily is nocturnal, but may be active throughout the day. It mostly forages for grasses and seeds (Fleharty and Olson, 1969; Schmidly, 1977*a*), but also may feed on insects (Cameron and Spencer, 1981) and eggs of ground nesting-birds (Davis and Schmidly, 1994). Food gathered during the warmer months is not stored for winter consumption (Davis and Schmidly, 1994). Rather, fat storage accumulated during spring, summer, and autumn aids in sustaining individuals over winter (Cameron and Spencer, 1981).

Nothing has been reported on the characteristics of seasonal molting in *S. hispidus*; no molting individuals were noted during this study.

Other species of rodents taken at the same localities as *S. hispidus* at BBRSP included *Reithrodontomys fulvescens*, *R. megalotis*, *Peromyscus leucopus*, *P. maniculatus*, and *P. pectoralis*.

Fleas were the only parasites noted on specimens of *S. hispidus* from BBRSP, and are the only ectoparasites previously reported from this cotton rat. Endoparasites known from *S. hispidus* include trematodes, cestodes, and nematodes. The hispid cotton rat reportedly harbors the following human pathogens: *Trypanosoma cruzi*, the rabies virus, the Venezuelan equine encephalomyelitis virus (Cameron and Spencer, 1981), and a strain of hantavirus (Childs et al., 1995).

Comments.— The subspecies of *S. hispidus* at BBRSP is *S. h. berlandieri* Baird, 1855. The generic name *Sigmodon* is derived from the Greek "sigma" and "odous," which translate to S-shaped and tooth, respectively. The specific epithet *hispidus* is Latin for shaggy (Stangl et al., 1993).

Specimens Examined (3).— Presidio Co.: BBRSP, UTM coordinates: 13 586937E 3262923N, 2; BBRSP, UTM coordinates: 13 595150E 3252057N, 1.

Sigmodon ochrognathus Bailey, 1902
Yellow-nosed Cotton Rat

Description.— *Sigmodon ochrognathus* is a small to medium-sized rat with a dorsal pelage similar to that describe for *S. hispidus*, but paler. The short hairs about the snout are distinctly orange. The tail is relatively short, lightly haired, and bicolored, being black above and rusty gray below. The dental formula for *S. ochrognathus* is: i 1/1, c 0/0, p 0/0, m 3/3, total 16.

External and cranial measurements of a single adult female from BBRSP are: total length, 229; length of tail vertebrae, 99; length of hind foot, 27; length of ear from notch, 18; weight, 58 (gravid); greatest length of skull, 30.14. Males and females do not vary in size (Baker and Shump, 1978).

S. ochrognathus could be mistaken for *S. hispidus*, but the two can be distinguished easily as described in the previous account.

Distribution.— The range of *S. ochrognathus* extends from north-central Mexico, northward into southwestern Texas, southwestern New Mexico, and southeastern Arizona (Baker and Shump, 1978). At BBRSP, *S. ochrognathus* is known from a single locality near Sauceda (Fig. 48).

Natural History.— During this study, one specimen of *S. ochrognathus* was taken, thus resulting in a relative abundance index of 0.008. This cotton rat comprised 0.1 percent of all rodents trapped at BBRSP. The specimen from BBRSP is the second documented from Presidio County (Yancey and Jones, 1996). These figures imply that *S. ochrognathus* is extremely rare in the park. At Big Bend National Park, this cotton rat was reported as common, but at high elevations, which are lacking at BBRSP (Borrell and Bryant, 1942; Schmidly, 1977*a*).

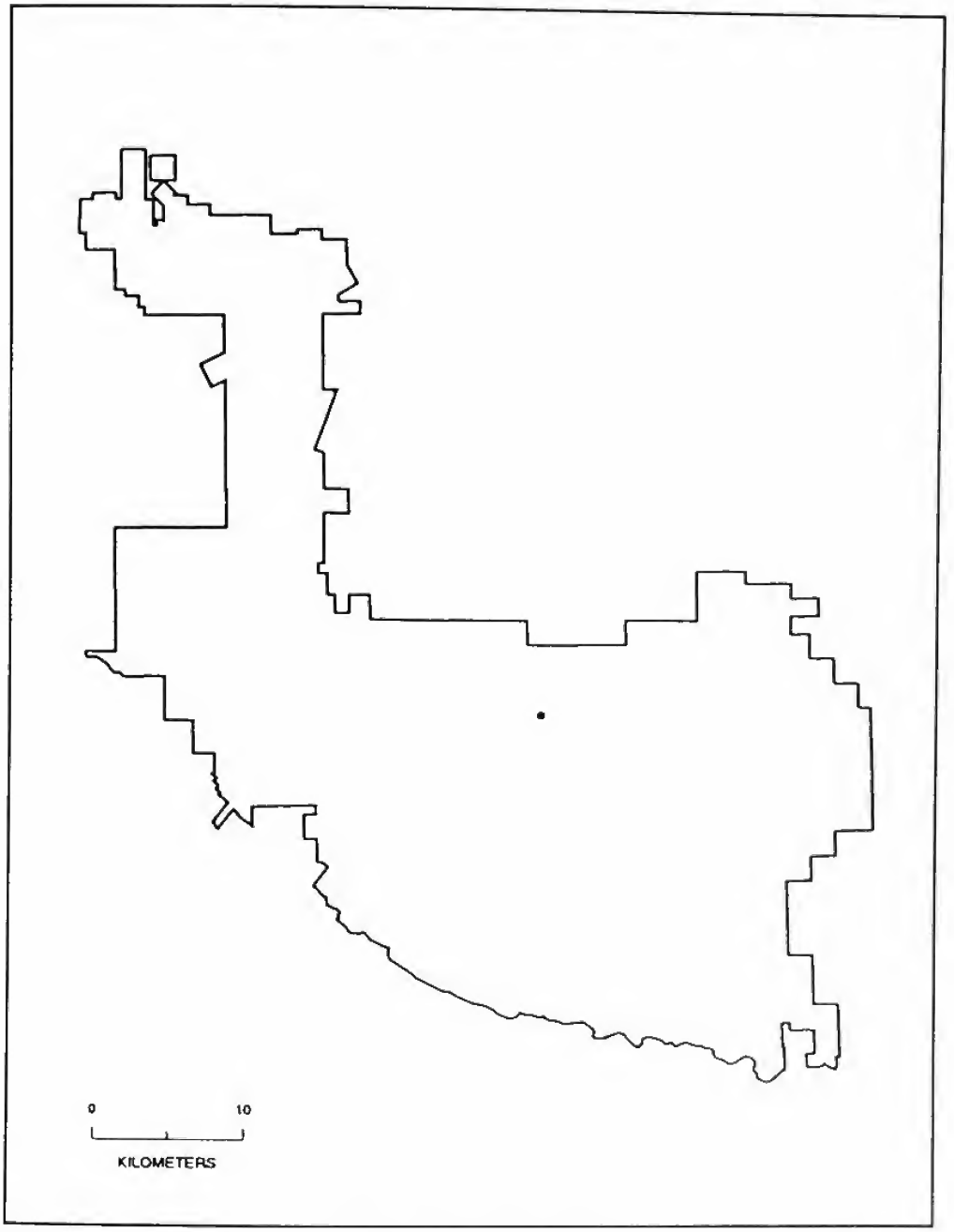

Figure 48. Localities of known specimens of *Sigmodon ochrognathus* from Big Bend Ranch State Park, Texas.

Throughout its range, *S. ochrognathus* reportedly favors high-elevation grasslands, as well as rocky upland slopes with scattered bunches of grasses (Baker, 1956; Findley and Jones, 1960; Baker, 1969; Anderson, 1972; Baker and Shump, 1978). The one yellow-nosed cotton rat taken at BBRSP was acquired from a lowland seasonal stream bed near a permanent spring. Associated vegetation included willow, false willow, and deergrass. The habitat surrounding the stream bed was desert scrub on a rugged, rocky substrate. This apparently is the first documented occurrence of *S. ochrognathus* from non-montane riparian habitat (Yancey and Jones, 1996).

The one yellow-nosed cotton rat taken during this study was acquired in August. This species is active year round (Schmidly, 1977*a*).

S. ochrognathus is reported to breed throughout the year. Female yellow-nosed cotton rats give birth to litters of three to five (mean, 3.6; Schmidly, 1977), possibly several times a year (Davis and Schmidly, 1994). A specimen obtained on 5 August was a gravid female carrying four embryos (crown-rump length, 9).

S. ochrognathus may be nocturnal or diurnal, but evidence suggests that it may be more active during the day (Davis and Schmidly, 1994). This cotton rat primarily feeds on grasses, but also consumes the fruits of prickly pear cactus (Schmidly, 1977*a*). Gathered grasses may be cached in burrows for future consumption (Baker and Shump, 1978).

I know of no data regarding annual molting in *S. ochrognathus*.

Other species of rodents taken at the same locality as *S. ochrognathus* at BBRSP included *Reithrodontomys fulvescens*, *R. megalotis*, *Peromyscus leucopus*, and *P. maniculatus*.

No parasites were observed in association with the specimen of *S. ochrognathus* from BBRSP. Fleas are the only parasites previously documented from yellow-nosed cotton rats (Baker, 1969).

Comments.— *S. ochrognathus* is a monotypic species. See the account on *Sigmodon hispidus* for the etymology of the generic name. The specific epithet *ochrognathus* is from the Greek "ochros" and "gnathos," meaning pale, and jaw, respectively (Stangl et al., 1993).

Specimens Examined (1).— Presidio Co.: BBRSP, UTM coordinates: 13 601619E 3260741N, 1.

Neotoma albigula Hartley, 1894
White-throated Woodrat

Description.—*Neotoma albigula* is a moderate to large woodrat with a buffy brown dorsal pelage that is lightly washed with black and gray. Hairs about the throat and chin are white entirely. The tail is moderate in length, densely furred with short hairs, and distinctly bicolored, and the ears are large. The dental formula for *N. albigula* is: i 1/1, c 0/0, p 0/0, m 3/3, total 16.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 301.8 (5, 268-327, 22.4); length of tail vertebrae, 131.4 (5, 110-149, 14.3); length of hind foot, 32.8 (6, 32-34, 0.8); length of ear from notch, 28.8 (6, 26-32, 2.1); weight, 164.6 (5, 128-182, 22.1); greatest length of skull, 42.01 (5, 39.01-44.05, 2.22). Males are larger than females (Macêdo and Mares, 1988).

N. albigula is confused most easily with *N. mexicana*. Typically, the two can be identified on the basis of throat hair color. The throat hairs in *N. albigula* are white entirely; whereas, those of *N. mexicana* usually are white above, but grayish at the base. However, this characteristic is not absolute in *N. mexicana*, as throat hairs occasionally may be white to the base. More reliably, these two woodrats can be differentiated on the basis of tooth morphology. In *N. albigula*, each first upper premolar has a shallow anterointernal reentrant angle that does not extend more than half-way across the crown. In contrast, the anterointernal reentrant angle of M1 in *N. mexicana* is deep, extending more than half-way across the crown. *N. albigula* can be distinguished from the other species of woodrat at BBRSP, *N. micropus*, by its buffy brown, rather than steel gray, dorsal pelage.

Distribution.— *N. albigula* ranges from central Mexico, northward throughout much of the southwestern United States (Macêdo and Mares, 1988). At BBRSP, this woodrat was recorded from sites in the Bofecillos Mountains, Chorro Canyon, and the Solitario (Fig. 49).

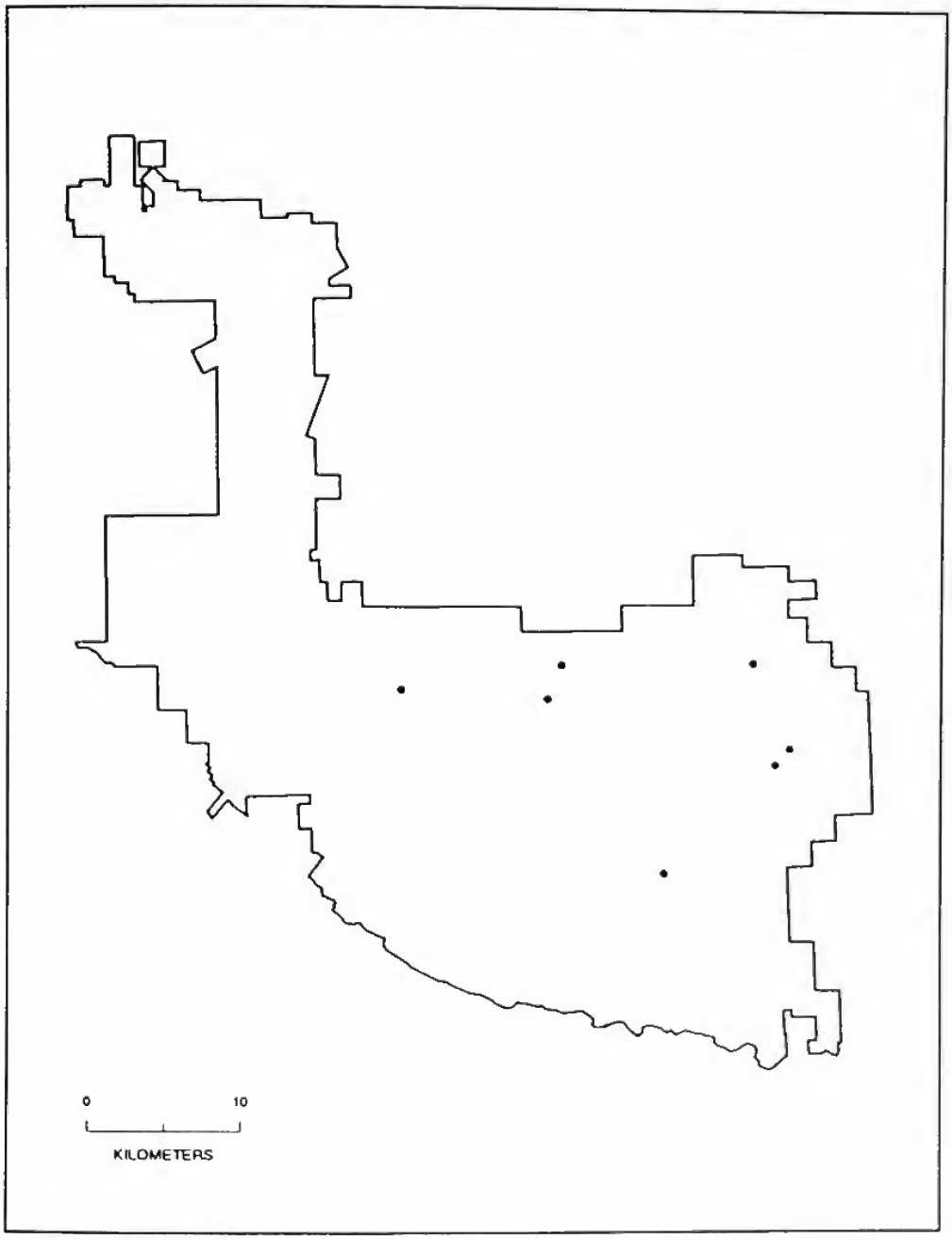

Figure 49. Localities of known specimens of *Neotoma albigula* from Big Bend Ranch State Park, Texas.

Natural History.— During this study, *N. albigula* was found to have a relative abundance index of 0.057. It accounted for 0.9 percent of all rodents taken at BBRSP. These results suggest that this woodrat is uncommon at the park.

N. albigula has been reported to inhabit a variety of plant associations, including desert scrub and grassland (Schmidly, 1977*a*), as long as prickly pear cactus is present (Macêdo and Mares, 1988). This woodrat is known to reside at intermediate elevations primarily

among rocks, within which it often constructs nests of sticks, cactus pads, and other materials (Finley, 1958; Schmidly, 1977*a*; Macêdo and Mares, 1988). During this study, *N. albigula* was taken in desert scrub and desert grassland, although it showed a significant preference for the latter (P=0.002). All individuals were acquired among rocks or boulders.

At BBRSP, *N. albigula* was taken only during January and February, but this species is active throughout the year (Macêdo and Mares, 1988).

Schmidly (1977*a*) reported the breeding season of *N. albigula* in the Trans-Pecos to last from early spring to the end of summer. In contrast, Baker (1956) concluded that this woodrat breeds year round in nearby Coahuila, Mexico. I examined a single gravid female on 5 February that was carrying one embryo with a crown-rump length of 41. Adult males had testes that measured 13 X 8 and 17 X 10 on 6 and 26 February, respectively. Given a gestation length of at least 37 days and perhaps more (Richardson, 1943), the breeding season of *N. albigula* at BBRSP begins as early as late December. Females produce two or possibly three litters of one to three young per year (Macêdo and Mares, 1988; Davis and Schmidly, 1994).

N. albigula primarily is nocturnal, although there is some evidence of diurnal activity (Macêdo and Mares, 1988). Succulent parts of prickly pear cactus are the primary material consumed by *N. albigula*. This item serves as both a food and water source for this woodrat (Finley, 1958). Additional foods include grasses, shrubs, and fruits (Macêdo and Mares, 1988). Small supplies of food may be found within dens, but food seldom is stored in large quantities, even in anticipation of winter (Finley, 1958).

In Colorado, *N. albigula* was reported to undergo a single annual molt that occurs from May to September (Finley, 1958). However, during this study, adult white-throated woodrats were observed molting in January and February. Because of its more southerly location, individuals at BBRSP may begin molting earlier.

Other species of rodents taken at the same localities as *N. albigula* at BBRSP included *Thomomys bottae*, *Dipodomys merriami*, *Peromyscus eremicus*, *P. pectoralis*, and *N. mexicana*. The sympatric and syntopic occurrence of *N. albigula* and *N. mexicana* is an interesting situation. Schmidly (1977*a*) suggests an elevational segregation of the two species, with *N. albigula* occurring at intermediate elevations and *N. mexicana* preferring high elevations above 1400 m. On the other hand, Macêdo and Mares (1988) imply a topographical separation, with *N. albigula* inhabiting moderately rocky slopes and *N. mexicana* residing among steep, rocky cliffs. At BBRSP, the site at which these two species were taken together was more typical of that preferred by *N. albigula*. It was in a moderately level area among small rocks at about 1300 m in elevation. Finley (1958) reported these two species, on a rare occasion, to nest under the same rock.

Ectoparasites detected on specimens of *N. albigula* from BBRSP were limited to mites and ticks. Other ectoparasites known from this woodrat include sucking lice and fleas. Endoparasites reported to infect *N. albigula* include cestodes (Finley, 1958). White-throated woodrats are known to harbor hantavirus (Stone, 1993).

Comments.— The subspecies of *N. albigula* at BBRSP is *N. a. robusta* Blair, 1939. The generic name *Neotoma* is derived from the Greek "neos" and "tomos," which translate to new and cutting, respectively. The specific epithet *albigula* is from the Latin "albus" and "gula," meaning white and throat, respectively (Stangl et al., 1993).

Specimens Examined (8).— Presidio Co.: BBRSP, UTM coordinates: 13 592898E 3261518N, 1; BBRSP, UTM coordinates: 13 602357E 3260937N, 1; BBRSP, UTM coordinates: 13 603273E 3263098N, 1; BBRSP, UTM coordinates: 13 615786E 3263185N, 2; BBRSP, South of Madrid Ranch, Chorro Canyon area, 1. Brewster Co.: BBRSP, UTM coordinates: 13 617223E 3256581N, 1; BBRSP, UTM coordinates: 13 618185E 3257611N, 1.

Neotoma mexicana Baird, 1855
Mexican Woodrat

Description.— *Neotoma mexicana* is a moderate to large woodrat with a buffy brown dorsal pelage that is moderately washed with black. Hairs about the throat and chin are white at the tips, and often gray at the base. The tail is short to moderate in length, densely furred with short hairs, and distinctly bicolored, and the ears are moderately large. The dental formula for *N. mexicana* is: i 1/1, c 0/0, p 0/0, m 3/3, total 16.

External and cranial measurements of an adult female from BBRSP are: total length, 315; length of tail vertebrae, 153; length of hind foot, 34; length of ear from notch, 29; weight, 141; greatest length of skull, 43.95. Males average larger than females (Finley, 1958).

N. mexicana is confused easily with *N. albigula*, but these two woodrats can be identified correctly as described in the previous account. *N. mexicana* can be distinguished from *N. micropus*, by its buffy brown, as opposed to steel gray, dorsal pelage.

Distribution.— *N. mexicana* ranges from Central America, northward throughout western and interior Mexico, into the United States where it occurs in Trans-Pecos Texas, New Mexico, Colorado, western Oklahoma, eastern Arizona, and southeastern Utah (Hall, 1981). At BBRSP, this woodrat has been documented only from one site in the Solitario (Fig. 50).

Natural History.— During this study, one Mexican woodrat was taken, which resulted in a relative abundance index of 0.001. This species accounted for only 0.1 percent of all rodents trapped. These figures indicate that *N. mexicana* is extremely rare at BBRSP.

N. mexicana is known to favor high-elevation (up to 2500 m) areas among rocky slopes and boulders (Finley, 1958; Schmidly, 1977*a*). Associated plant communities usually are shrubland or wooded areas (Finley, 1958). The specimen from BBRSP was taken in desert grassland with scattered lechuguilla and sotol. The site was relatively level with a rocky substrate. This woodrat, unlike other woodrats, usually does not build an elaborate nest of sticks and other debris. Instead, it dens in the crevices among large rocks and boulders (Finley, 1958). However, large rocks and boulders were lacking at the site where this woodrat was taken in BBRSP. Apparently, *N. mexicana* will build a nest of sticks and other material if a natural rock shelter is absent from the area (Finley, 1958).

In the Trans-Pecos, the breeding season of *N. mexicana* reportedly extends from early spring to the end of summer (Schmidly, 1977*a*; Davis and Schmidly, 1994). However, I examined a lactating female on 26 February, thus indicating that breeding may begin in winter at BBRSP. Litter sizes range from two to five with an average of about 3.5 (Schmidly, 1977*a*). Based on the length of the breeding season, Finley (1958) speculated that females may produce two litters a year.

Like other woodrats, *N. mexicana* forages at night and stores food in its den for daytime feeding. This woodrat feeds primarily on the leaves of forbs and shrubs, but also may consume fruits, flowers, and woody vegetation. In contrast to *N. albigula*, *N. mexicana* exhibits a strong distaste for cactus. Also unlike *N. albigula*, *N. mexicana* readily stores large quantities of food, presumably for consumption over winter. Mexican woodrats typically reside at higher elevations than do white-throated woodrats, and thus face longer, colder winters, and possible food shortages during that time (Finley, 1958).

Annual molting in *N. mexicana* has been documented to occur from April through December (Finley, 1958), but males and females may molt at different times. The single adult taken during this study was molting on 26 January, thus extending the period of which this woodrat is known to molt.

Other species of rodents taken at the same locality as *N. mexicana* at BBRSP included *Thomomys bottae*, *Dipodomys merriami*, *Peromyscus eremicus*, and *N. albigula*. See the previous account for a discussion on the sympatric occurrence of *N. mexicana* and *N. albigula*.

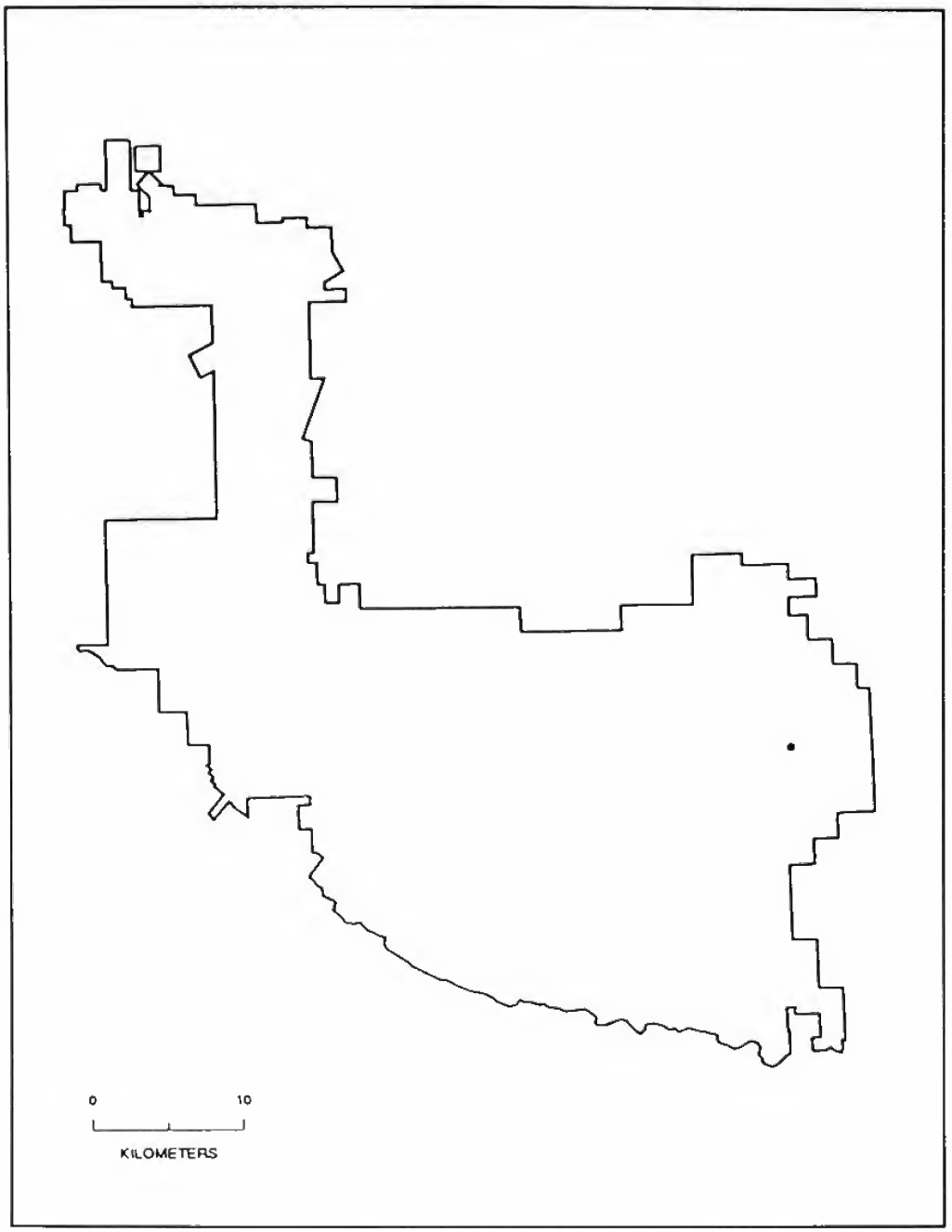

Figure 50. Localities of known specimens of *Neotoma mexicana* from Big Bend Ranch State Park, Texas.

Mites were noted infesting the specimen of *N. mexicana* from BBRSP. Other ectoparasites previously reported from *N. mexicana* include ticks, fleas, and lice. Cestodes are the only documented internal parasites of Mexican woodrats (Finley, 1958).

Comments.— The subspecies of *N. mexicana* at BBRSP is *N. m. mexicana* Baird, 1855. See the account on *Neotoma albigula* for the etymology of the generic name. The specific epithet *mexicana* refers to of Mexico (Stangl et al., 1993).

Specimens Examined (1).— Brewster Co.: BBRSP, UTM coordinates: 13 618185E 3257611N, 1.

Neotoma micropus Baird, 1855
Southern Plains Woodrat

Description.—*Neotoma micropus* is a moderate to large woodrat with a fairly uniform steel gray dorsal pelage. The tail is short to moderate in length, lightly furred with short hairs, and distinctly bicolored, and the ears are medium to large. The dental formula for *N. micropus* is: i 1/1, c 0/0, p 0/0, m 3/3, total 16.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 298.7 (10, 265-332, 19.7); length of tail vertebrae, 122.7 (10, 105-134, 8.3); length of hind foot, 34.4 (10, 32-36, 1.3); length of ear from notch, 26.1 (10, 24-28, 1.1); weight, 143.8 (8, 91-225, 43.3); greatest length of skull, 41.90 (9, 39.15-45.67, 1.97). Males are larger than females (Finley, 1958).

N. micropus conceivably could be confused with *N. albigula* and *N. mexicana*. See the accounts of these two species for differentiation.

Distribution.— *N. micropus* ranges from northeastern and north-central Mexico, northward into the United States where it occurs in the western two thirds of Texas, much of New Mexico, western Oklahoma and Kansas, and southeastern Colorado (Braun and Mares, 1989). This woodrat is known from scattered localities in BBRSP (Fig. 51).

Natural History.— With a relative abundance index of 0.097, *N. micropus* accounted for 1.5 percent of all rodents trapped at BBRSP. Considering rodents in general, these figures suggest that *N. micropus* is uncommon in the park. However, this was the most commonly trapped large murid, and frequent sightings of its nests suggest that *N. micropus* is more abundant than trapping results indicate.

Throughout its range, *N. micropus* is known to inhabit a variety of habitats (Braun and Mares, 1989). In Trans-Pecos Texas, this woodrat apparently favors lowland desert scrub and grasslands where cactus or thorny desert shrubs occur, and tends to avoid rocky cliffs (Schmidly, 1977*a*). During this study, *N. micropus* was taken only from lowland desert scrub and grassland, with no significant difference in capture rates between these two habitats (P=0.167). Prickly pear cactus, creosote, mesquite, and catclaw were plants commonly associated with this woodrat. Large, elaborate nests, which are characteristic of this species (Finley, 1958), often were noted at the bases of these plants. These dens usually were constructed of sticks, cactus pads, and other debris.

During this study, *N. micropus* was taken during January, February, June, and July. This woodrat remains active throughout the year, but may spend a greater proportion of time in the den during winter (Braun and Mares, 1989).

In parts of its range, *N. micropus* is known to breed throughout the year. However, Schmidly (1977*a*) reported that in the Trans-Pecos, this woodrat breeds only in early spring. I examined two gravid females from BBRSP, one on 4 February (2 embryos, crown-rump length, 9), and the other on 2 June (2 embryos, crown-rump length, 10). A subadult was noted on 1 June. Testicular measurements of adult males were as follows: 12 January, 16 X 9; 14 January, 14 X 9; 23 May 14 X 7; 22 June, 15 X 10. These figures indicate that at BBRSP, *N. micropus* is reproductively active at times other than early spring. Given a gestation period that ranges from 30 to 39 days (Braun and Mares, 1989), and embryos on 4 February and 2 June with a crown-rump lengths of 9 and 10, respectively, mating must have occurred in late December and mid-May. In addition, males with enlarged testes during January, May, and June suggest that breeding occurs in winter, late spring, and possibly early summer. Therefore, it is possible that the breeding season of *N. micropus* extends throughout the year, as it does in south Texas (Raun, 1966), or at least from winter to late spring. Litter sizes range from one to four, but two or three is the norm. In the Trans-Pecos, females were thought to produce only a single litter each year (Schmidly, 1977*a*). However,

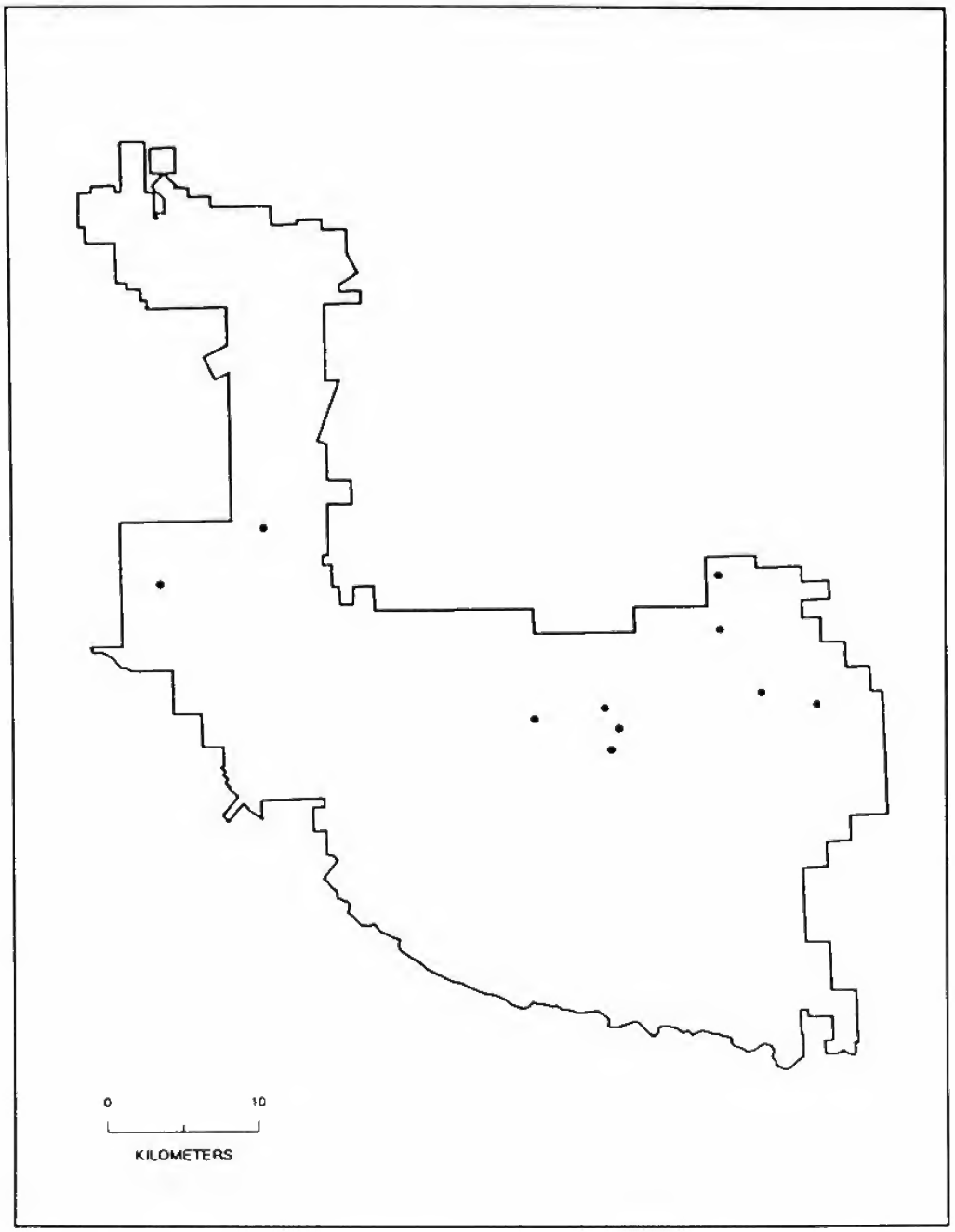

Figure 51. Localities of known specimens of *Neotoma micropus* from Big Bend Ranch State Park, Texas.

this assumption was based on the premise that the breeding season of this woodrat was restricted to early spring. With an extended breeding period as suggested above, *N. micropus* conceivably could produce multiple litters annually, as does the species in other parts of its range (Birney, 1973).

N. micropus is nocturnal, with most activity occurring between dusk and midnight (Raun, 1966). At twilight, this woodrat begins foraging for foods such as the pads and fruit of prickly pear cactus, sotol leaves, the blades of lechuguilla and yucca, and mesquite beans (Finley, 1958; Schmidly, 1977*a*; Braun and Mares,

1989). In addition to food, *N. micropus* also relies on many of these items for its water supply (Finley, 1958; Davis and Schmidly, 1994). Southern plains woodrats occasionally cache small amounts of food for daytime feeding, but not for use over winter (Finley, 1958).

In the southern part of its range, adult southern plains woodrats reportedly molt once a year during summer or fall, and the process usually is complete by November (Birney, 1973). During this study, I examined molting adults during January, February, May, June, and July. Birney (1973) also noted adults molting at various times during the year that were inconsistent with a single autumn molt. He termed these molts "vernal molts," and explained them as mechanisms to maintain the pelage that may be complete, abbreviated, or absent.

Other species of rodents taken at the same localities as *N. micropus* at BBRSP included *Perognathus flavus*, *Chaetodipus eremicus*, *C. nelsoni*, *Dipodomys merriami*, *Reithrodontomys megalotis*, *Peromyscus eremicus*, and *P. maniculatus*.

Fleas were the only external parasites found on specimens of *N. micropus* from BBRSP. In addition to fleas, other ectoparasites known to infest this woodrat include mites, ticks, lice, and botfly larvae. Known internal parasites include protozoans, cestodes, and nematodes. Of medical significance, the protozoan *Trypanosoma cruzi*, which is responsible for Chaga disease, is known to infect *N. micropus* (Braun and Mares, 1989).

Comments.— The subspecies of *N. micropus* at BBRSP is *N. m. canescens* J. A. Allen, 1891. See the account on *Neotoma albigula* for the etymology of the generic name. The specific epithet *micropus* is from the Greek "mikros" and "pous," meaning small and foot, respectively (Stangl et al., 1993).

Specimens Examined (11).— Presidio Co.: BBRSP, UTM coordinates: 13 576206E 3268568N, 1; BBRSP, UTM coordinates: 13 583096E 3272189N, 1; BBRSP, UTM coordinates: 13 600694E 3259751N, 1; BBRSP, UTM coordinates: 13 605201E 3260431N, 1; BBRSP, UTM coordinates: 13 605576E 3257735N, 1; BBRSP, UTM coordinates: 13 606085E 3259112N, 1; BBRSP, UTM coordinates: 13 612594E 3268946N, 1; BBRSP, UTM coordinates: 13 612683E 3265440N, 1; BBRSP, UTM coordinates: 13 615371E 3261358N, 1. Brewster Co.: BBRSP, UTM coordinates: 13 619081E 3260561N, 2.

Family Erethizontidae

Erethizon dorsatum (Linnaeus, 1758) Porcupine

Description.— *Erethizon dorsatum* is a large rodent with distinct dorsal pelage that consists of long, yellowish and brown guard hairs intermixed with pale, dark tipped quills. The tail is relatively short, and the ears are small. The dental formula for *E. dorsatum* is: i 1/1, c 0/0, p 1/1, m 3/3, total 16.

No measurements of *E. dorsatum* from BBRSP were obtained. Woods (1973) listed the following ranges of external and cranial measurements for the species: total length, 645 to 1030; length of tail vertebrae, 145 to 300; length of hind foot, 75 to 91; weight, 3.5 to 18 kg; greatest length of skull, 93 to 112. Males average considerably larger than females (Schmidly, 1977*a*).

The unique nature of the dorsal pelage of *E. dorsatum* makes it impossible to confuse this rodent with any other mammal at BBRSP.

Distribution.— *E. dorsatum* ranges from northern Mexico, northward throughout most of the western and northeastern United States, and across most of Canada and Alaska (Woods, 1973). No specimens of *E. dorsatum* are known from BBRSP, but it has been reported from the Fresno Canyon area (Scudday, 1976*b*).

Natural History.— During this study, *E. dorsatum* was neither taken nor observed. Scudday (1976*b*) re-

ported occasional encounters with porcupines at BBRSP, but found little evidence of tree damage caused by this rodent. He speculated that predation by mountain lions probably was responsible for the low numbers of porcupines in the area. Based on this information, *E. dorsatum* should be considered rare at BBRSP. However, the porcupine is known to exhibit considerable fluctuations in its population sizes (Woods, 1973), therefore its status at the park is subject to changed.

In the Trans-Pecos, *E. dorsatum* is known to prefer rocky, forested mountains, as opposed to the flats, valleys, and gulches (Schmidly, 1977*a*) typical of BBRSP. The lack of suitable forested areas undoubtedly contributes to the scarcity of this rodent in the park.

Porcupines are active throughout the year (Roze, 1989), but may exhibit a decrease in activity during extended cold periods (Woods, 1973).

In the Trans-Pecos, *E. dorsatum* breeds in late summer or early autumn, with the young being born in April or May (Schmidly, 1977*a*). The gestation period of about 210 days is uncharacteristically long for a rodent (Roze, 1989). Typically a single young is born, but apparently there are rare instances of twins (Woods, 1973).

E. dorsatum typically forages at night (Roze, 1989). The diet of this rodent varies by season. During the cooler months, porcupines subsist on the inner bark of trees, whereas in the warmer months, they feed on a variety of plant parts including roots, stems, berries, seeds, and flowers (Woods, 1973). Thermophylic cellulose-decomposing bacteria present in the gut aid in the digestion of these foods (Dodge, 1982). Porcupines do not receive adequate quantities of sodium in there diet, and therefore must actively ingest items that contain large amounts of this element, such as soil, salt-rich plants, and bone (Roze, 1989).

E. dorsatum usually molts during summer, at which time the underfur becomes short or absent (Woods, 1973).

Ectoparasites reported from *E. dorsatum* include mites, lice, fleas, and ticks (Roze, 1989). One of the mites, *Sarcoptes scabei*, is the etiologic agent of scabies (Woods, 1973), and severe epidemics of this disease have been reported among porcupines . Endoparasites known from porcupines include cestodes and nematodes (Roze, 1989).

Comments.— The subspecies of *E. dorsatum* at BBRSP is *E. d. epixanthum* Brandt, 1835. The generic name *Erethizon* is Greek for to irritate. The specific epithet *dorsatum* is derived from the Latin "dorsum," meaning back (Stangl et al., 1993).

Specimens Examined (0).

ORDER CARNIVORA—CARNIVORES

Family Canidae (Dogs and Allies)

Canis latrans Say, 1823
Coyote

Description.— *Canis latrans* is a medium-sized canine with a grayish-buffy dorsal pelage that is washed with black, resulting in a grizzled appearance. The muzzle is long and narrow, the tail long, bushy, and black-tipped, and the ears are of moderate size. The dental formula for *C. latrans* is: i 3/3, c 1/1, p 4/4, m 2/3, total 42, but according to Davis and Schmidly (1994) molars may be 2/2, 3/2, or 3/3, resulting in a total of 40, 42, or 44 teeth.

No measurements of adult *C. latrans* specimens from BBRSP were obtained. Schmidly (1977*a*) lists the following means of external measurements for coyotes from the Trans-Pecos: total length, 1200; length of tail vertebrae, 400; length of hind foot, 180. The weight of coyotes ranges from 14 to 20 kg (Davis and Schmidly, 1994). The greatest length of skull measurement for the subspecies that occurs in BBRSP averages about 200. Males average larger than females (Bekoff, 1977).

Of the canids known from BBRSP, *C. latrans* is confused most easily with *C. familiaris*, the domestic dog. However, most domestic dogs do not have the general appearance as that described above for the coyote, and these two canids usually are distinguished rather easily. In addition, cranial features of *C. latrans* and *C. familiaris* differ. In *C. latrans*, the lateral view of the dorsal profile of the skull is relatively straight, and the upper tooth row is greater than 3.1 times the width of the palate. In contrast, the lateral view of the dorsal profile of the skull shows a bulging forehead, and the upper tooth row is less than 3.1 times the palatal width in *C. familiaris* (Howard, 1949). *C. latrans* is distinguished easily from *Vulpes velox* and *Urocyon cinereoargenteus*, the only other canids at the park, by its larger size.

Distribution.— *C. latrans* ranges from Central America, northward throughout Mexico, most of the United States and Canada, and into Alaska (Bekoff, 1977). One specimen of *C. latrans* from BBRSP exists from the Sauceda area (Fig. 52). In addition, coyotes were seen or heard at several locations throughout the park.

Natural History.— Only one specimen of *C. latrans* was taken during this study, but animals and signs were observed on countless occasions. Based on these observations, *C. latrans* should be considered common in BBRSP.

C. latrans is adapted for a variety of habitats (Jones and Birney, 1988), but in the Trans-Pecos, seems to favor desert scrub and grasslands (Schmidly, 1977*a*), which may, in part, account for its abundance at BBRSP. The specimen taken at the park during this study was acquired from desert scrub dominated with creosote, opuntia, and mesquite. In addition, coyotes frequently were sighted in both desert scrub and grassland.

Coyotes are known to be active throughout the year (Bekoff, 1977) and were observed as such at BBRSP.

The breeding season of *C. latrans* in the Trans-Pecos extends from January to March, with parturition occurring from April through June (Schmidly, 1977*a*). Litter sizes vary in response to population densities (Knowlton, 1972) and food abundance , but in general, range from four to seven (Bekoff, 1977), with an average of 5.1 (Knowlton, 1972). Females are monestrous, giving birth to a single litter a year (Bekoff, 1977). At BBRSP, a subadult was noted on 1 June.

C. latrans primarily is nocturnal and crepuscular, but may be active at any time of the day (Caire et al., 1989). This canine tends to be most active in the early morning and around sunset (Bekoff, 1982). The diet of the coyote is extremely catholic and varies by geography and season. Major food items consumed by coyotes include lagomorphs, rodents, birds, carrion, invertebrates, and fruits. In addition, *C. latrans* occasionally preys on large game animals, such as deer, and on domestic livestock. In these instances, young, old, and sick prey individuals primarily are targeted (Bekoff, 1977).

Typically, a single seasonal molt occurs in *C. latrans*. This takes place between late spring and early fall, with the guard hairs and undercoat of the summer pelage being shorter than those of the winter pelage (Bekoff, 1977).

No parasites were noted on the one coyote taken at BBRSP. This canid is known to harbor numerous parasites. Ectoparasites known from *C. latrans* include ticks, fleas, and lice. Endoparasites known to infect *C. latrans* include numerous cestodes, and nematodes. Pathogenic organisms that afflict coyotes include the plague and tularemia bacilli (*Yersinia pestis* and *Francisella tularensis*, respectively), and the distemper and rabies viruses (Bekoff, 1977).

Comments.— The subspecies of *C. latrans* at BBRSP is *C. l. texensis* Bailey, 1905. The generic name *Canis* is Latin for dog. The specific epithet *latrans* is from the Latin "latrare," meaning bark (Stangl et al., 1993).

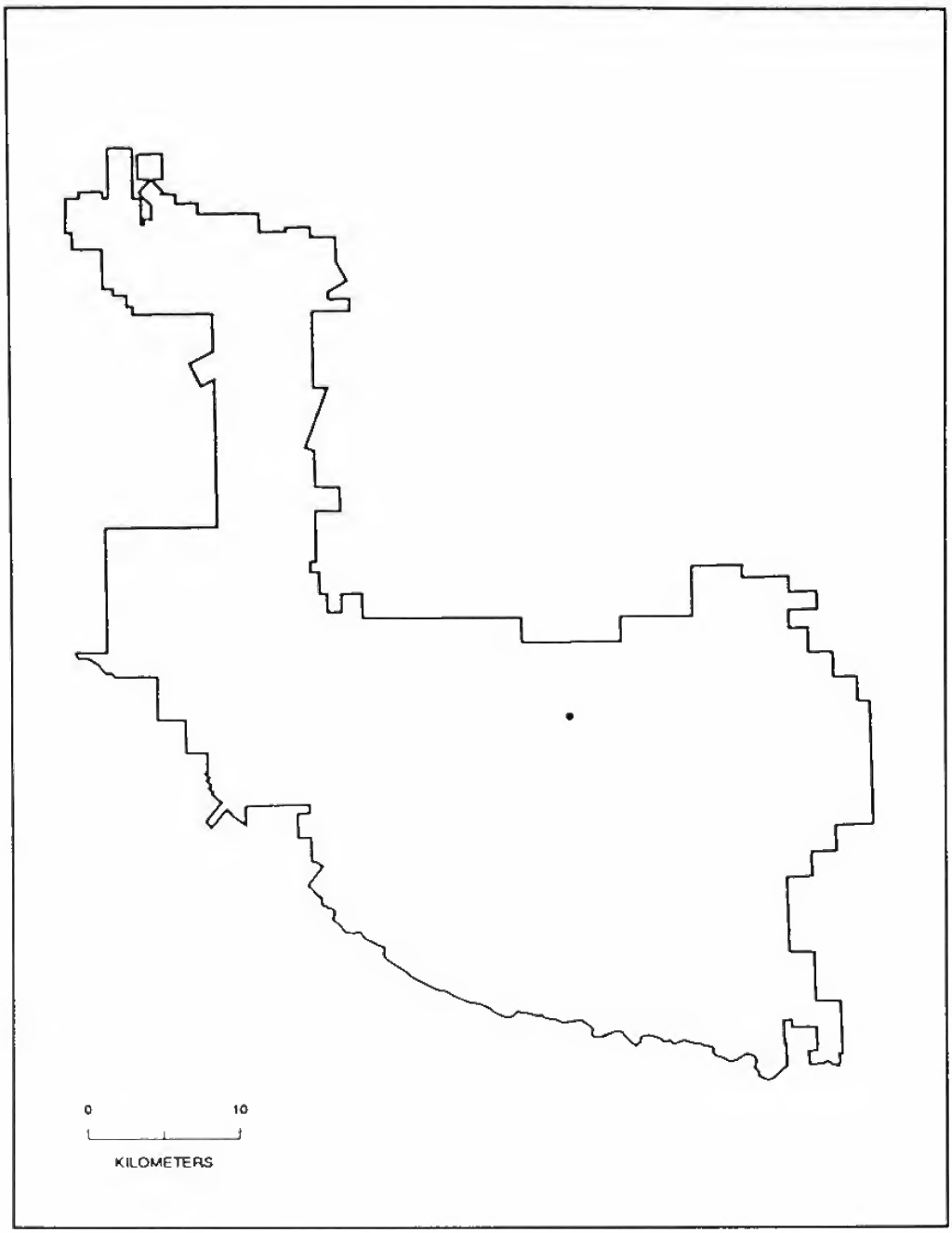

Figure 52. Localities of known specimens of *Canis latrans* from Big Bend Ranch State Park, Texas.

Specimens Examined (1).— Presidio Co.: BBRSP, UTM coordinates: 13 603790E 3260448N, 1.

Vulpes velox (Say, 1823)
Kit Fox

Description.— *Vulpes velox* is a small fox with a pale, grizzled gray dorsal pelage. The tail is long and bushy, and is gray in color except for a black tip. The ears are noticeably large. The dental formula for *V. velox* is: i 3/3, c 1/1, p 4/4, m 2/3, total 42.

No external or cranial measurements of *V. velox* from BBRSP were obtained. Mean external measurements (with sample size and extremes in parentheses) for the kit foxes in general are: total length, 788 (19, 730-840); length of tail vertebrae, 290 (19, 260-323); length of hind foot, 122 (19, 113-137); length of ear from notch, 85 (19, 78-94). Greatest length of skull measurements of 35 specimens averaged 114.4. The mean weight of *V. velox* is about 2.1 kg . Secondary sexual dimorphism has not been documented, but males tend to weigh more than females (McGrew, 1979).

V. velox might be mistaken for *Canis latrans*, *C. familiaris*, or *U. cinereoargenteus*. However, the small size and fox-like appearance distinguish it from members of the genus *Canis*. The large ears and black-tipped (but not striped) tail distinguish the two foxes. In addition, the skull of *U. cinereoargenteus* has temporal ridges that form the shape of a lyre, and each dentary has a noticeable step at the posterioventral end, whereas the temporal ridge in *V. velox* is not lyre-shaped, and the lower margin of each dentary is smooth.

Distribution.— The range of *V. velox* extends from north-central Mexico, northward throughout much of the western United States (Egoscue, 1979; McGrew, 1979). Previously, it was known to occur as far north as south-central Canada, but this fox may have become extirpated from that area (Egoscue, 1979). *V. velox* has been documented in BBRSP, but specific localities of its presence in the park are unknown.

Natural History.— *V. velox* was not documented at BBRSP during this study. Pittman (1995) reported its presence in the park where he estimated its density at 0.1 individuals per km^2 during one year. These data indicate that the kit fox is rare in BBRSP.

In the Trans-Pecos, kit foxes inhabit open desert country, and seem to be absent from rough, rocky situations (Schmidly, 1977*a*). There are no data available as to the type of habitat in which kit foxes were encountered at BBRSP.

The only encounters of *V. velox* at BBRSP has been during the fall (Pittman, 1995). This fox is known to remain active throughout the year (Brown and Wernette, 1988).

The breeding season of *V. velox* extends from December through February. After an estimated gestation period of 49 to 55 days, four or five pups are born in February or March (Samuel and Nelson, 1982). Females are monestrous, breeding once a year (McGrew, 1979). *V. velox* is monogamous, and has been reported by some to mate for life (Jones et al., 1983).

V. velox primarily is nocturnal, but may be active at anytime during the day (Davis and Schmidly, 1994). This fox relies on a variety of foods, including lagomorphs, rodents, birds, grasses (Samuel and Nelson, 1982), and insects (Brown and Wernette, 1988). In addition to nutrition, prey items may supply the water requirements of this fox (McGrew, 1979).

No information is available regarding annual molting in kit foxes.

Ectoparasites associated with *V. velox* include fleas and ticks. Internal parasites include protozoans, cestodes, and nematodes (Samuel and Nelson, 1982). One of the cestodes harbored by this fox (*Dipylidium caninum*) occasionally infects humans (Brown, 1975).

Comments.— The subspecies of *V. velox* at BBRSP is *V. v. macrotis* (Merriam, 1888). The generic name *Vulpes* is Latin for fox. The specific epithet *macrotis* is from the Greek "makros" and "ous," meaning long and ear, respectively (Stangl et al., 1993). Previously, the kit fox and swift fox were considered distinct species, *V. macrotis* and *V. velox*, respectively (Wozencraft, 1993). However, based on morphological and electrophoretic data, Dragoo et al. (1990) sunk *macrotis* to subspecific status under *velox*.

Specimens Examined (0).

Urocyon cinereoargenteus (Schreber, 1775)
Gray Fox

Description.— *Urocyon cinereoargenteus* is a medium-sized fox with a grizzled gray dorsal pelage that is the result of guard hairs banded with white, gray, and black. The sides and legs are rusty, and a black stripe is present along the dorsum of the bushy tail. The ears are moderate in size. The dental formula for *U. cinereoargenteus* is: i 3/3, c 1/1, p 4/4, m 2/3, total 42.

External and cranial measurements of an adult male from BBRSP are: total length, 1001; length of tail vertebrae, 441; length of hind foot, 140; length of ear from notch, 75; weight, 2.1 kg; greatest length of skull, 125.16. Males tend to be slightly larger than females (Fritzell and Haroldson, 1982).

U. cinereoargenteus might be mistaken for *Canis latrans* or *C. familiaris*. However, the unique pelage coloration and its fox-like appearance distinguish the former from the latter two. In addition, the skull of *U. cinereoargenteus* has temporal ridges that form a distinct lyre-shape, and each dentary has a noticeable truncated indentation or "step" at the posterioventral end, characteristics that are absent from the skulls of other canids known from BBRSP.

Distribution.— The range of *U. cinereoargenteus* extends from southern South America, northward across Central America and Mexico, and throughout the United States, excluding most of the northwestern fourth of the country. It reaches its northern limits in southern Canada (Fritzell and Haroldson, 1982). In BBRSP, this fox has been documented only from one locality in the Los Alamos area (Fig. 53). An additional individual was sighted just outside the park boundary in the Cienega area.

Natural History.— Only one specimen of *U. cinereoargenteus* was collected during this study, and no additional individuals were sighted in BBRSP. These data suggest that the gray fox is rather uncommon in BBRSP.

In the Trans-Pecos, gray foxes are known to prefer mountainous regions with piñon-juniper forests. They reportedly associate with cliffs and canyons in these montane areas and usually do not occur in open desert or grassland that lacks juniper (Schmidly, 1977*a*), typical of most of BBRSP. The gray fox taken at BBRSP during this study was found in a shallow canyon with a small stream in the bottom. Associated vegetation included willow, false willow, cottonwood, oak, and walnut. The habitat above of the canyon was juniper roughland. The scarcity of juniper-associated habitats probably accounted for the rarity of this fox at BBRSP.

U. cinereoargenteus is active throughout the year (Fritzell and Haroldson, 1982). The specimen taken at BBRSP was acquired in March, and the individual observed near the park was sighted in November.

The breeding season of *U. cinereoargenteus* varies geographically (Samuel and Nelson, 1982). In the Trans-Pecos, this fox apparently breeds from January through March (Schmidly, 1977*a*). An adult male from BBRSP had testes measuring 24 X 14 on 24 March. After a 53 to 63 day gestation period, one to seven (mean, 3.8, mode, 4) pups are born. Following birth, males assist the females in raising the pups until autumn, at which time the pups begin to disperse (Schmidly, 1977*a*).

U. cinereoargenteus is mostly nocturnal or crepuscular, but may be active during the daytime (Fritzell and Haroldson, 1982). Gray foxes are adept climbers; some foraging takes place in trees (Fritzell and Haroldson, 1982). The diet of this canid is diverse, and varies seasonally and geographically. Principal foods consumed include rabbits, rodents, juniper berries and other fruits, invertebrates, and fresh carrion (McKinnerney, 1978; Fritzell and Haroldson, 1982).

Adult gray foxes undergo a single annual molt that extends from summer through autumn (Grinnell et al., 1937).

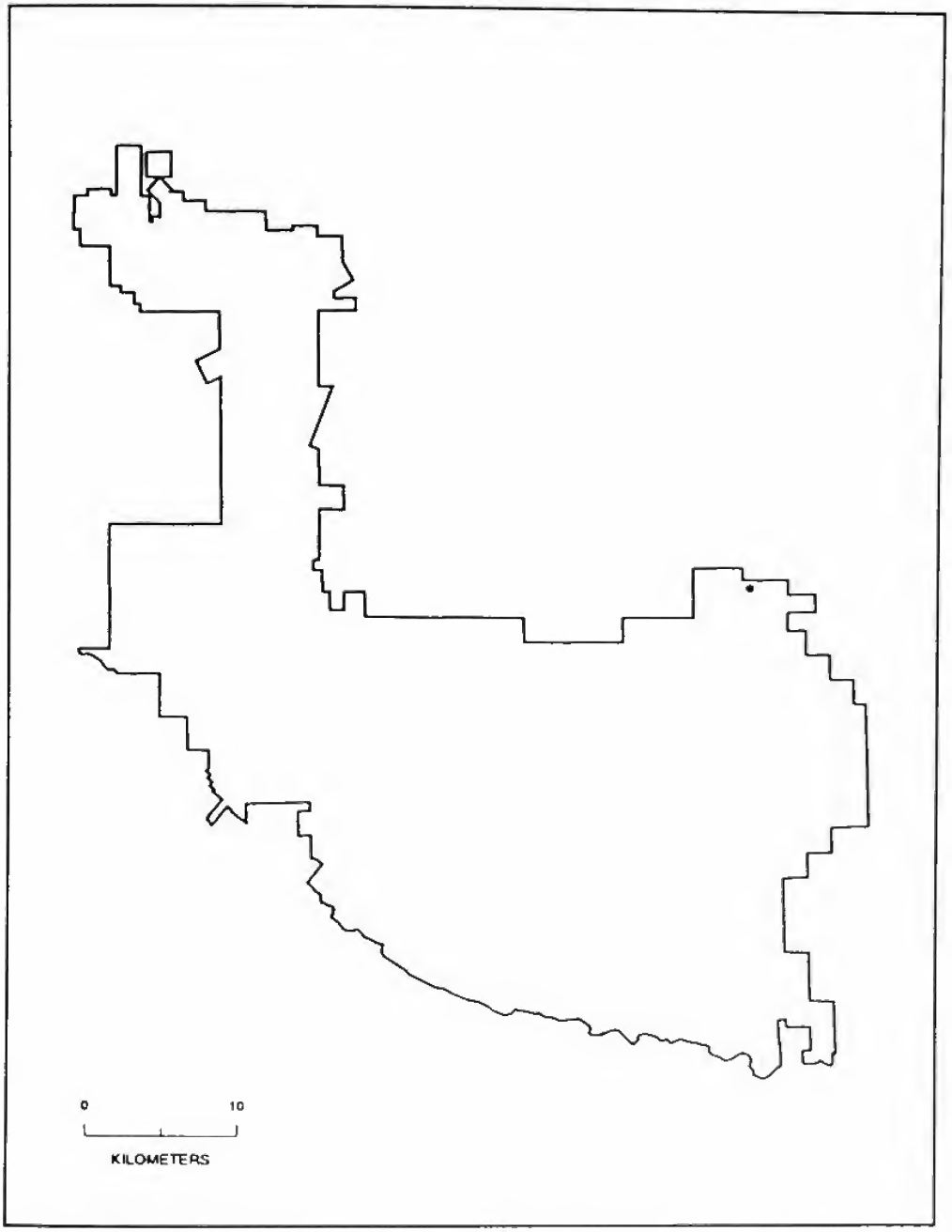

Figure 53. Localities of known specimens of *Urocyon cinereoargenteus* from Big Bend Ranch State Park, Texas.

Another carnivore, *Bassariscus astutus*, was taken at the same locality at BBRSP as *U. cinereoargenteus*.

No parasites were noted in association with the one gray fox from BBRSP. Ectoparasites that *U. cinereoargenteus* is known to host include multiple species of mites, lice, and fleas. Endoparasites that infect this canid include trematodes, cestodes, and nematodes. Bacterial diseases known to afflict gray foxes include tularemia (*Francisella tularensis*), listeriosis (*Listeria monocytogenes*), and leptospirosis (*Letptospira* sp.). Viral diseases include rabies, canine distemper, and St. Louis encephalitis. The fungal disease histoplasmosis (*Histoplasma capsulatum*) and the rickettsial disease Q-fever (*Coxiella burnetii*) also occur in *U. cinereoargenteus* (Fritzell and Haroldson, 1982).

Comments.— The subspecies of *U. cinereoargenteus* at BBRSP is *U. c. scottii* Mearns, 1891. The generic name *Urocyon* is derived from the Greek "oura" and "kyon," which translate to tail and dog, respectively. The specific epithet *cinereoargenteus* is from the Greek "cinereus" and "argenteus," meaning ashen and silver, respectively (Stangl et al., 1993).

Specimens Examined (1).— Presidio Co.: BBRSP, UTM coordinates: 13 615599E 3268863N, 1.

Family Ursidae (Bears)

Ursus americanus Pallas, 1780
Black Bear

Description.— *Ursus americanus* is a large, robust carnivore with a dorsal pelage that ranges from cinnamon to brown to black in color. It has relatively short, stocky legs, a short tail, and small ears. Short, curved claws are present on all feet. The dental formula for *U. americanus* is: i 3/3, c 1/1, p 4/4, m 2/3, total 42.

No measurements of *U. americanus* specimens from BBRSP were obtained. Schmidly (1977*a*) lists the following means of external measurements for black bears from the Trans-Pecos: total length, 1500; length of tail vertebrae, 125; length of hind foot, 175. Black bears usually weigh between 54 and 158 kg, although they may weigh as much as 340 kg . Males are considerably larger than females (Ford, 1981).

Because of its large size and unique appearance, *U. americanus* cannot be mistaken for any other mammal that occurs at BBRSP.

Distribution.— *U. americanus* ranges from north-central Mexico, northward throughout most of the United States and Canada, including Alaska (Hall, 1981). No specimens of *U. americanus* are known from BBRSP. However, sightings of this bear have been reported from the Los Alamos area within the past five years.

Natural History.— *U. americanus* was neither collected nor sighted at BBRSP during this study. However, during the autumn of 1994, a female black bear and her two cubs were relocated to the park from a site near Langtree, Texas. Soon after their release, the three bears wandered outside BBRSP, apparently headed towards Big Bend National Park (Anonymous, 1995*c*). With the exception of these translocated individuals, the last black bear sighting at BBRSP was by a ranger about five years ago. Currently, *U. americanus* should be considered rare or possibly extirpated from BBRSP.

Black bears typically inhabit wooded and forested areas (Nowak, 1991), but have been known to occur in the rugged lowlands of the Trans-Pecos (Schmidly, 1977*a*). The last sighting of a non-introduced black bear occurred in juniper woodland. The lack of adequate wooded areas, along with excessive hunting and overgrazing (Schmidly, 1977*a*), probably account for scarcity of black bears at BBRSP.

U. americanus hibernates in the colder parts of its range (Davis and Schmidly, 1994), but is thought to be active throughout the year in Coahuila, Mexico (Baker, 1956). I assume the latter situation to apply to black bears in the BBRSP area.

Black bears generally breed in June or July. Following a gestation period of about 220 days, females give birth to one to five (usually 2 or 3) cubs in January or February. Females typically breed every other year (Nowak, 1991).

U. americanus may be nocturnal, diurnal, or crepuscular, depending on the season and location (Ford, 1981). This bear feeds on a variety of plant and animal materials, but the former comprises at least 75 percent of its diet (Nowak, 1991). Typical food items include fruits, berries, nuts, grasses, roots, insects, rodents, birds, carrion, honey, and occasionally large mammals (Jones et al., 1983; Nowak, 1991). In nearby Coahuila,

Mexico, Baker (1956) found seasonal variation in the diet of black bears. Acorns were its main food in winter spring and fall, whereas fruits, berries, and animal products dominated the menu in late spring, summer, and early fall. Sotol shoots and yucca leaves and blooms may be eaten at various times during the year. Occasionally, black bears may kill livestock, but these instances apparently are few (Nowak, 1991). Male black bears frequently cannibalize young bears (Bauer, 1985).

U. americanus begins its annual molt in late spring. The process is gradual, not being completed until mid-autumn (Bauer, 1985).

Ectoparasites known from *U. americanus* include ticks, lice, and fleas (Pelton, 1982). Endoparasites include protozoans (Pelton, 1982), trematodes, and nematodes (Ford, 1981; Jones et al., 1983; 1985). One of the nematodes that commonly infects *U. americanus* is *Trichinella spiralis*, the causative agent of trichinosis (Brown, 1975; Ford, 1981). Black bears also are known to be infected with the spirochaete *Leptospira* sp., the etiologic agent of leptospirosis (Ford, 1981).

Comments.— The subspecies of *U. americanus* at BBRSP is *U. a. amblyceps* Baird, 1859. The generic name *Ursus* is Latin for bear. The specific epithet *americanus* refers to of (North) America (Stangl et al., 1993).

Specimens Examined (0).

Family Procyonidae (Raccoons and Allies)

Bassariscus astutus (Lichtenstein, 1830)
Ringtail

Description.— *Bassariscus astutus* is a small, cat-like carnivore with a tan to pale brown dorsal pelage that is washed heavily with black. The tail is long and bushy, and does not taper. The underside of the tail is whitish, whereas the top is distinctly annulated with 14 to 16 alternating dark brown and white rings. The ears are relatively moderate in size. All feet have five digits and bear semi-retractile claws. The dental formula for *B. astutus* is: i 3/3, c 1/1, p 4/4, m 2/2, total 40.

External and cranial measurements of a two adult males from BBRSP are: total length, 708, 788; length of tail vertebrae, 348, 415; length of hind foot, 68, 73; length of ear from notch, 52, 50; weight, 950, 1300; greatest length of skull, 76.51, 83.07. Males generally are larger than females (Poglayen-Neuwall and Toweill, 1988, Davis and Schmidly, 1994).

The only other mammal at BBRSP that *B. astutus* might be confused with is *P. lotor*. However, these two procyonids are distinguished easily on the basis of size and build. *B. astutus* is small and rather slender, whereas *P. lotor* is larger and stout. Furthermore, the tail of *B. astutus* is long (longer than the head and body) and has 14-16 alternating rings of white and dark, as opposed to a short tail (less than length of head and body) with five to seven alternating buff and dark rings in *P. lotor*.

Distribution.— The range of *B. astutus* extends from southern Mexico, northward throughout Mexico, thence across the south-central, southwestern, and much of the western United States (Poglayen-Neuwall and Toweill, 1988). In BBRSP, ringtails have been recorded from the Cienega and Los Alamos areas (Fig. 54).

Natural History.— Two ringtails were taken during this study, and a third was sighted. However, *B. astutus* undoubtedly is more common in BBRSP than these figures indicate. Relatively little effort was made to trap these small carnivores, and they are known to be quite secretive (Jones et al., 1985). In addition, what appeared to be ringtail scat frequently was observed among rocks in suitable habitat. Therefore, I believe *B. astutus* to be fairly common in BBRSP.

B. astutus is known to inhabit a variety of habitats. This procyonid favors areas with rocky outcroppings, or canyons associated with vegetation such as juniper and oak. Ringtails also are known to exploit riparian woodlands for their abundance of food and water (Poglayen-Neuwall and Toweill, 1988). The

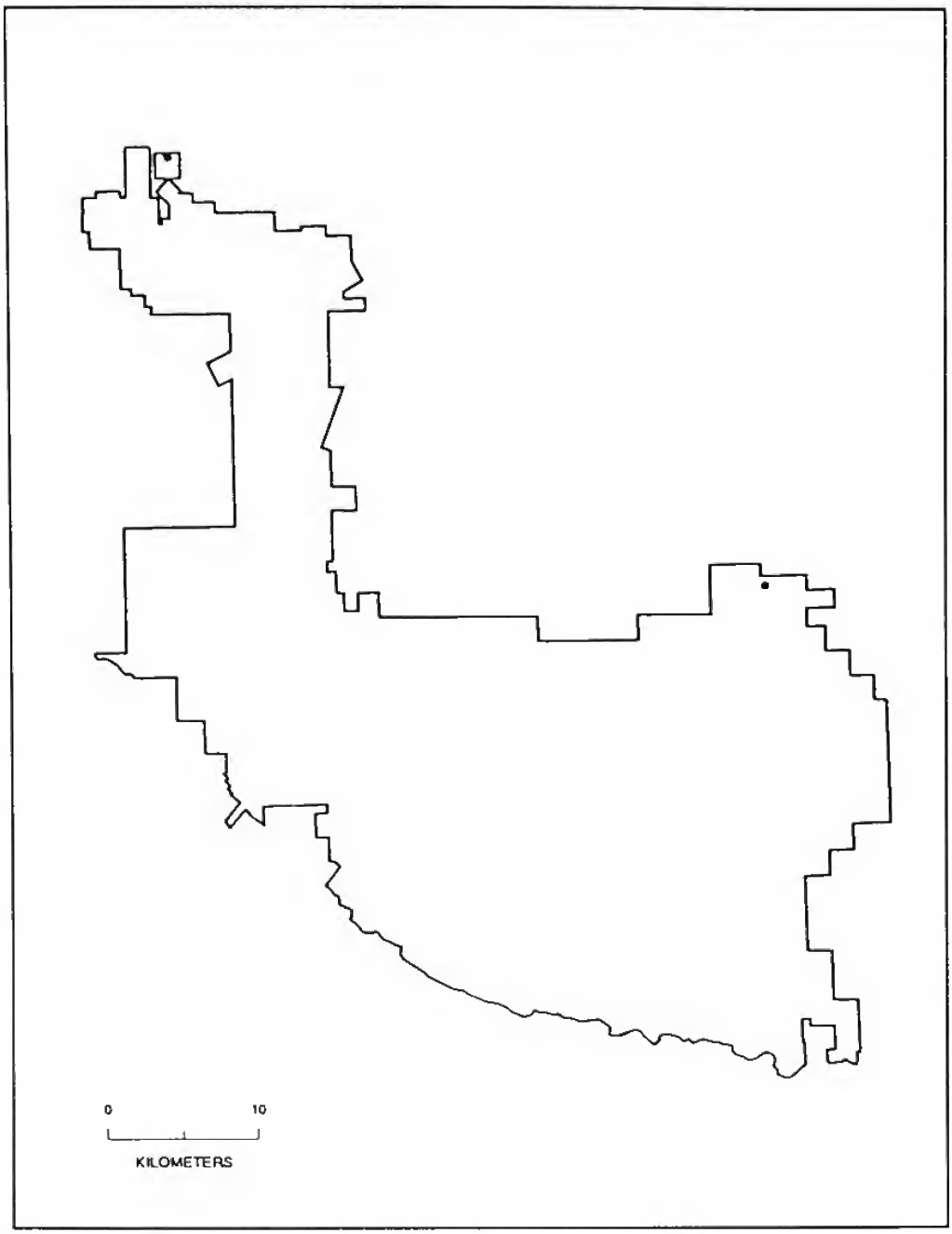

Figure 54. Localities of known specimens of *Bassariscus astutus* from Big Bend Ranch State Park, Texas.

two specimens acquired, as well as the one individual sighted, were in riparian woodland. Vegetation at two of the sites was dominated by willow, false willow, and cottonwood. Both of these sites were relatively flat and rocky outcroppings were absent. The third site where *B. astutus* was encountered was in a shallow canyon with a small stream at the bottom. Associated vegetation included, oak, willow, false willow, walnut, and cottonwood. The area above the canyon was dominated by juniper and various scrub species.

During this study, *B. astutus* was taken or observed in March and November. This mammal does not hibernate (Caire et al., 1989) and should be considered active year round.

B. astutus, in general, breeds from February to May, but most mating occurs during March and April (Poglayen-Neuwall and Toweill, 1988). The little reproductive data available from the Trans-Pecos indicate that breeding in the region is ongoing in April (Schmidly, 1977*a*). Adult males taken during this study had testes measuring 15 X 11 and 10 X 6 on 3 May and 8 November, respectively. The enlarged testes noted in May suggest that breeding in BBRSP continues into that month. Gestation ranges from 51 to 54 days, and parturition, therefore, probably occurs mostly in May and June (Poglayen-Neuwall and Toweill, 1988). Litter sizes range from one to five (Poglayen-Neuwall and Toweill, 1988), but average about three (Schmidly, 1977*a*).

B. astutus is almost strictly nocturnal, although some crepuscular activity has been documented (Poglayen-Neuwall and Toweill, 1988). This mammal is omnivorous, feeding on a wide variety of foods (Kaufmann, 1982). Some primary food items include small mammals, arthropods, and fruits (Poglayen-Neuwall and Toweill, 1988). Ringtails are excellent climbers (Jones et al., 1985), and some foraging undoubtedly takes place up in trees. Due to an aversion to daylight that is acquired shortly after birth (Toweill and Toweill, 1978) and persists in adults (Kavanau and Ramos, 1975), ringtails rarely are active during the day (Poglayen-Neuwall and Toweill, 1988). However, during this study, an adult individual was sighted at 1200 h on a bright, sunny day. It was sitting motionless on a large, unshaded rock next to a stream. Ringtails are known to occasionally feed on frogs and fish (Poglayen-Neuwall and Toweill, 1988), and possibly this individual was foraging for these vertebrates, as both were abundant in the stream.

Seasonal molting in adult ringtails commences in late summer and is complete by late autumn (Poglayen-Neuwall and Toweill, 1988). At BBRSP, a molting adult was observed on 8 November.

Other species of carnivores taken at the same localities as *B. astutus* at BBRSP included *Urocyon cinereoargenteus*, *Procyon lotor*, *Conepatus mesoleucus*, and *Mephitis mephitis*.

No parasites were observed in association with *B. astutus* from BBRSP. Ectoparasites previously reported from ringtails include mites, ticks, lice, and fleas. Endoparasites known from *B. astutus* include cestodes and nematodes. Ringtails are known to be afflicted by the rabies virus (Poglayen-Neuwall and Toweill, 1988).

Comments.— The subspecies of *B. astutus* at BBRSP is *B. a. flavus* Rhoads, 1894. The generic name *Bassariscus* is derived from the Greek "bassara," which translates to fox. The specific epithet *astutus* is Latin for cunning (Stangl et al., 1993).

Specimens Examined (2).— Presidio Co.: BBRSP, UTM coordinates: 13 576790E 3296211N, 1; BBRSP, UTM coordinates: 13 615404E 3268775N, 1.

Procyon lotor (Linnaeus, 1758)
Common Raccoon

Description.— *Procyon lotor* is a stout, medium-sized carnivore with a dorsal pelage that is composed of coarse black, brown, buff, and rusty hairs, resulting in an overall grizzled grayish-black appearance. An obvious dark mask is present on the otherwise pale-colored face. The tail is relatively short, bushy, and has five to seven alternating dark brown and light buffy rings. The ears are fairly small. All feet have five digits and bear non-retractile claws. The dental formula for *P. lotor* is: i 3/3, c 1/1, p 4/4, m 2/2, total 40.

External and cranial measurements of an adult male from BBRSP are: total length, 785; length of tail vertebrae, 242; length of hind foot, 110; length of ear from notch, 60; weight, 5.0 kg; greatest length of skull, 114.54. Males are larger than females (Lotze and Anderson, 1979).

P. lotor might be confused with the other procyonid known from BBRSP, *B. astutus,* but is distinguished easily as described in the previous account.

Distribution.— *P. lotor* ranges from southern Central America, northward throughout Mexico, most of the United States, and much of southern Canada (Lotze and Anderson, 1979). In BBRSP, one specimen of *P. lotor* is known from the Cienega area (Fig. 55). In addition, raccoons were noted at Sauceda, Lava Canyon, and along the Rio Grande.

Natural History.— Only one specimen of *P. lotor* was acquired during this study, but the distinct tracks of this mammal were observed on several occasions. Schmidly (1977*a*) reported raccoons as common in suitable habitat throughout the Trans-Pecos, and this undoubtedly is the situation at BBRSP.

Throughout its range, *P. lotor* utilizes a variety of habitats (Lotze and Anderson, 1979), and in the Trans-Pecos occurs just about anywhere there is a source of water (Schmidly, 1977*a*). All signs of raccoons noted at BBRSP were in areas associated with abundant water. An individual was taken and several tracks were noted in riparian woodlands dominated by willow, cottonwood, and false willow. Additional tracks were seen along the Rio Grande among salt cedar, tree tobacco, and giant reed. Other tracks were noticed in drainages transecting desert scrub.

During this study, *P. lotor* was noted during July and September. Raccoons, may exhibit a decrease in activity during cold periods, but do not hibernate (Lotze and Anderson, 1979) and should be considered active year round at BBRSP.

The reproductive habits of *P. lotor* vary throughout its range (Lotze and Anderson, 1979). In the Trans-Pecos, raccoons mate during February and March (Schmidly, 1977*a*). Following a gestation period of 60 to 73 days (Davis and Schmidly, 1994), two to four (mean, 3) young are born in April or May (Schmidly, 1977*a*). On rare occasions, a second litter may be produced (Lotze and Anderson, 1979). An adult male from BBRSP taken on 6 September had testes measuring 31 X 16.

Raccoons primarily are nocturnal (Jones et al., 1983), although they are known to wander toward foraging sites as early as 1600 h. They are omnivores, and seem to consume whatever foods are available. Major food items of *P. lotor* include berries, nuts, and seeds of various plants, as well as miscellaneous invertebrates. Vertebrates are eaten at a lesser degree (Lotze and Anderson, 1979). Raccoons commonly are thought to wash their food prior to ingesting it. However, they may be feeling their food, rather than washing it, as individuals are known to rub their food between their hands in the absence of water (Whitney, 1933).

The annual molt in *P. lotor* begins in spring (Jones et al., 1985) and lasts throughout much of the summer (Lotze and Anderson, 1979). New guard hairs appear in fall, and by December, the pelage is in full winter condition (Jones et al., 1985).

Other species of carnivores taken at the same locality as *P. lotor* at BBRSP included *Bassariscus astutus*, *Conepatus mesoleucus*, and *Mephitis mephitis*.

No parasites were noted in association with the specimen of *P. lotor* from BBRSP. Previously reported ectoparasites include ticks, lice, and fleas. Known endoparasites include protozoans, trematodes, cestodes and nematodes. In addition, raccoons are known to harbor several agents known to cause disease in humans, including the protozoan *Trypanosoma cruzi* (Chaga disease), the bacteria *Francisella tularensis* (tularemia), *Leptospira* sp. (leptospirosis), and *Mycobacterium* sp. (tuberculosis), and the rabies virus (Lotze and Anderson, 1979; Jones et al., 1983).

Comments.— The subspecies of *P. lotor* at BBRSP is *P. l. fuscipes* Mearns, 1914. The generic name *Procyon* is derived from the Greek "pro" and "kyon," which translate to before and dog, respectively. The specific epithet *lotor* is modern Latin for washer (Stangl et al., 1993).

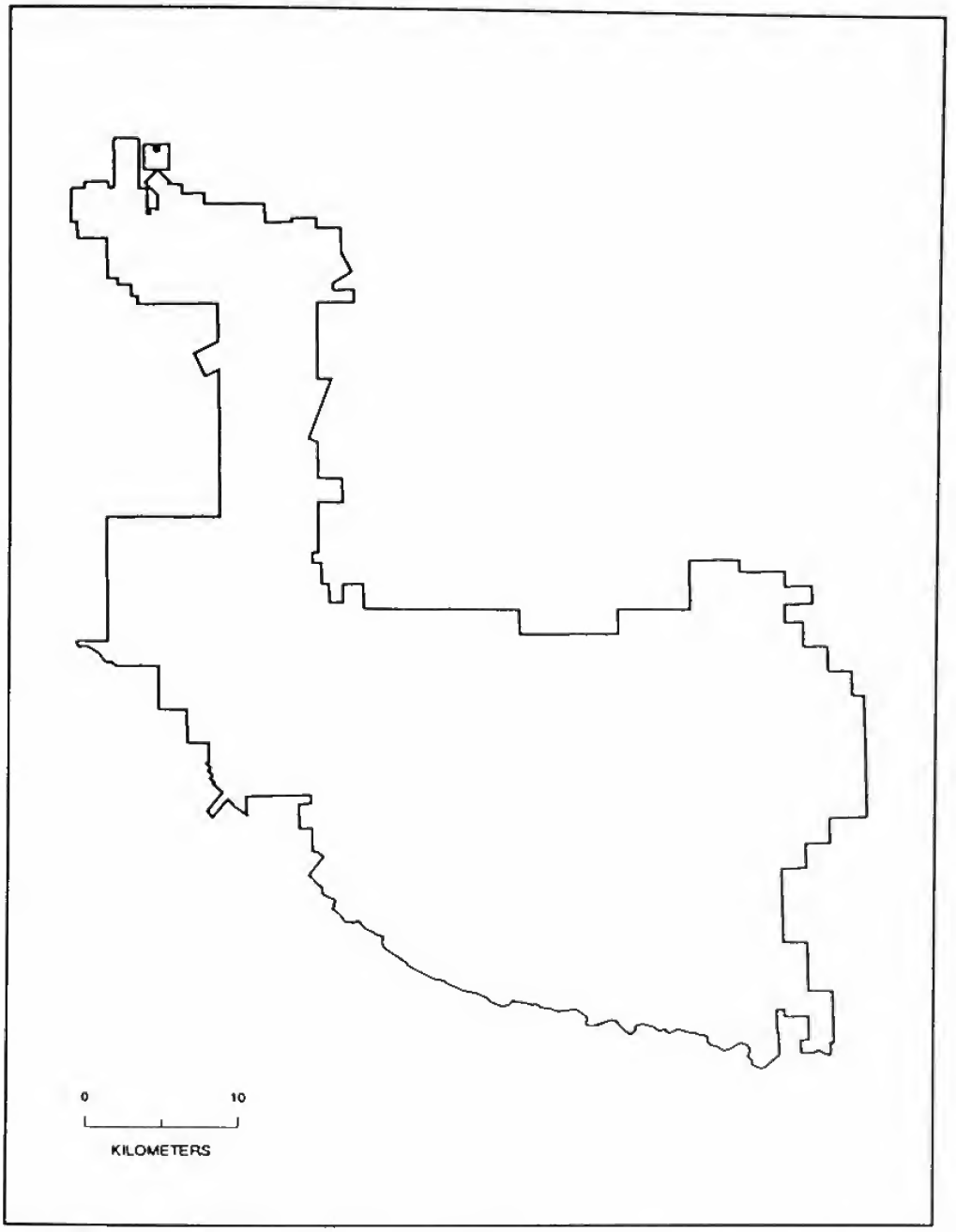

Figure 55. Localities of known specimens of *Procyon lotor* from Big Bend Ranch State Park, Texas.

Specimens Examined (1).— Presidio Co.: BBRSP, UTM coordinates: 13 576783E 3296202N, 1.

Family Mustelidae
(Weasels, Skunks, and Allies)

***Taxidea taxus* (Schreber, 1777)**
American Badger

Description.— *Taxidea taxus* is a stout, short-legged mustelid with shaggy, grayish brown dorsal pelage. A white mid-dorsal stripe extends posteriorly from

the nose as far back as the rump. Each side of the face has a black patch or "badge" that is surrounded by white. The tail is short, broad, and bushy, and the ears are small. All feet have five digits, the forefeet bearing long claws, and the hind feet with much shorter claws. The dental formula for *T. taxus* is: i 3/3, c 1/1, p 3/3, m 1/2, total 34.

No measurements of *T. taxus* from BBRSP were obtained. Schmidly (1977*a*) reported the following average external measurements for male and female badgers, respectively, from the Trans-Pecos: total length, 788, 730; length of tail vertebrae, 133, 150; length of hind foot, 120, 114. The weight of badgers ranges from 4 to 10 kg (Davis and Schmidly, 1994). A single specimen taken just outside BBRSP had a greatest length of skull measurement of 125.37. Males are larger than females (Long, 1973).

Its short, stout build and coloration of its pelage easily distinguish *T. taxus* from all other mammals known from BBRSP.

Distribution.— *T. taxus* ranges from central Mexico, northward throughout the western three fourths of the United States and Canada (Long, 1973). No specimens of *T. taxus* are known from BBRSP. However, it has been sighted in the Terneros Creek area, and a specimen was collected just outside the park in the Cienega area.

Natural History.— *T. taxus* was not collected at BBRSP during this study, and it was seen only on rare occasions. Badgers are not known to be common anywhere in the Trans-Pecos (Schmidly, 1977*a*), and apparently that is the situation at BBRSP.

Badgers are known to occur in a variety of habitats (Davis and Schmidly, 1994), but in the Trans-Pecos they seem to prefer desert flats and grasslands (Schmidly, 1977*a*). All sightings of badgers occurred in lowland desert scrub dominated by creosote-bush. A specimen collected just outside the park was found in that type of habitat.

T. taxus was encountered in the vicinity of BBRSP during May and August. It does not hibernate, although it may spend proportionally more time in its underground den during cold weather (Lindzey, 1982).

Badgers breed during late July and August. Following fertilization, implantation of the blastocyst is delayed until February. Parturition occurs in late march or early April, at which time one to five young are born (Lindzey, 1982).

T. taxus primarily is nocturnal (Lindzey, 1982) or crepuscular (Jones et al., 1983), but may be active during the day as well (Long, 1973). Young of the year tend to be more diurnal than adults (Lindzey, 1982). Badgers primarily prey on burrowing rodents, especially ground squirrels, but also will feed on other mammals, invertebrates, birds, snakes, and carrion (Long, 1973; Lindzey, 1982; Jones et al., 1983; Davis and Schmidly, 1994). Food items sometimes are cached in old dens for future consumption (Lindzey, 1982). There are reports of badgers teaming with coyotes in an effort to catch rodents (Long, 1973).

Annual molting in adult badgers occurs in summer or fall (Jones et al., 1983).

Ectoparasites known to infest *T. taxus* include ticks, lice, and fleas. Various trematodes, cestodes, and nematodes are endoparasites reported from badgers. Agents of medical significance that *T. taxus* harbors include the nematode *Trichinella spiralis*, the bacterium *Francisella tularensis*, and the rabies virus. In addition, antibodies to *Yersinia pestis* have been detected in badgers (Lindzey, 1982).

Comments.— The subspecies of *T. taxus* at BBRSP is *T. t. berlandieri* Baird, 1858. The generic name *Taxidea* is derived from the modern Latin "taxus" and Greek "idea," which translate to badger and form, respectively. The specific epithet *taxus* is modern Latin for badger (Stangl et al., 1993).

Specimens Examined (0).

Mephitis mephitis (Schreber, 1776)

Striped Skunk

Description.— *Mephitis mephitis* is a medium-sized skunk with a dorsal pelage that is solid black with two white stripes, one on each side of the back. Schmidly (1977*a*) reported that three different stripe patterns exist among striped skunks from the Trans-Pecos. In each pattern, the two stripes are joined at the neck region where they divide into a "V." In the broad-stripe phase, two relatively wide stripes extend from the neck to the rump. The narrow-stripe phase is similar, except that both stripes are fairly slender. The short-stripe pattern is similar to the narrow-stripe pattern, except that the two stripes extend only about halfway down the back. All striped skunks taken or observed at BBRSP were of the narrow-stripe variety. A narrow, white stripe is present between the eyes on the rostrum and forehead. The tail of this skunk is long, bushy, and usually consists of both black and white hair, although black seems to predominate. The ears are short and round. All feet have five digits; the forefeet bearing long, curved claws, and the hind feet with shorter, straighter claws. The dental formula for *M. mephitis* is: i 3/3, c 1/1, p 3/3, m 1/2, total 34.

Means of external and cranial measurements (with sample size, extremes, and standard deviation in parentheses) of adult specimens from BBRSP are: total length, 649.2 (6, 620-696, 27.0); length of tail vertebrae, 302.5 (6, 260-341, 31.3); length of hind foot, 69.8 (6, 65-73, 3.3); length of ear from notch, 28.2 (6, 26-30, 1.8); weight, 1552 (6, 1150-2200, 391.2); greatest length of skull, 71.12 (6, 67.69-73.82, 2.55). Males are significantly larger than females (Wade-Smith and Verts, 1982).

M. mephitis can be distinguished easily from *C. mesoleucus*, the only other skunk known from BBRSP, by having two narrow dorsal stripes as opposed to a single broad dorsal stripe as found in *C. mesoleucus*. Furthermore, *M. mephitis* has three upper premolars on each side, whereas *C. mesoleucus* has two.

Distribution.— *M. mephitis* ranges from northern Mexico, northward throughout the United States and much of Canada (Wade-Smith and Verts, 1982). In BBRSP, *M. mephitis* was taken only in the Cienega area (Fig. 56), but was sighted in the Sauceda area and along the Rio Grande as well.

Natural History.— Six striped skunks were trapped during this study, and several additional individuals were sighted. This species has been reported as common throughout the Trans-Pecos (Schmidly, 1977*a*) as well as in parts of northern Coahuila (Baker, 1956), and evidently is common in BBRSP.

Throughout their range, striped skunks are known to utilize various habitats (Wade-Smith and Verts, 1982), but in parts of the Chihuahuan Desert reportedly favor rough, rocky terrain (Schmidly, 1977*a*) and low elevation riparian habitats (Baker, 1956). All individuals taken or sighted during this study were among the latter. The six striped skunks that were collected were trapped in riparian woodland dominated by willow, false willow, and cottonwood. An individual was sighted near the Rio Grande in association with salt cedar.

At BBRSP, striped skunks were encountered during May, July, August, September, and November. *M. mephitis* does not hibernate, but in the northern part of its range, enters a period of prolonged inactivity during winter. Throughout Texas, this skunk is active year round, but may show less activity during summer (Godin, 1982).

M. mephitis breeds once (rarely twice) a year, usually in February or March. Following a gestation period of approximately 60 days, two to 10 (mean, 5) kits are born in April or May (Schmidly, 1977*a*; Godin, 1982). At BBRSP, lactating females were noted on 3 and 6 July. Testicular measurements of males were as follows: 2 May, 19 X 14; 3 September, 20 X 10; 4 November, 17 X 13; 26 November, 22 X 6.

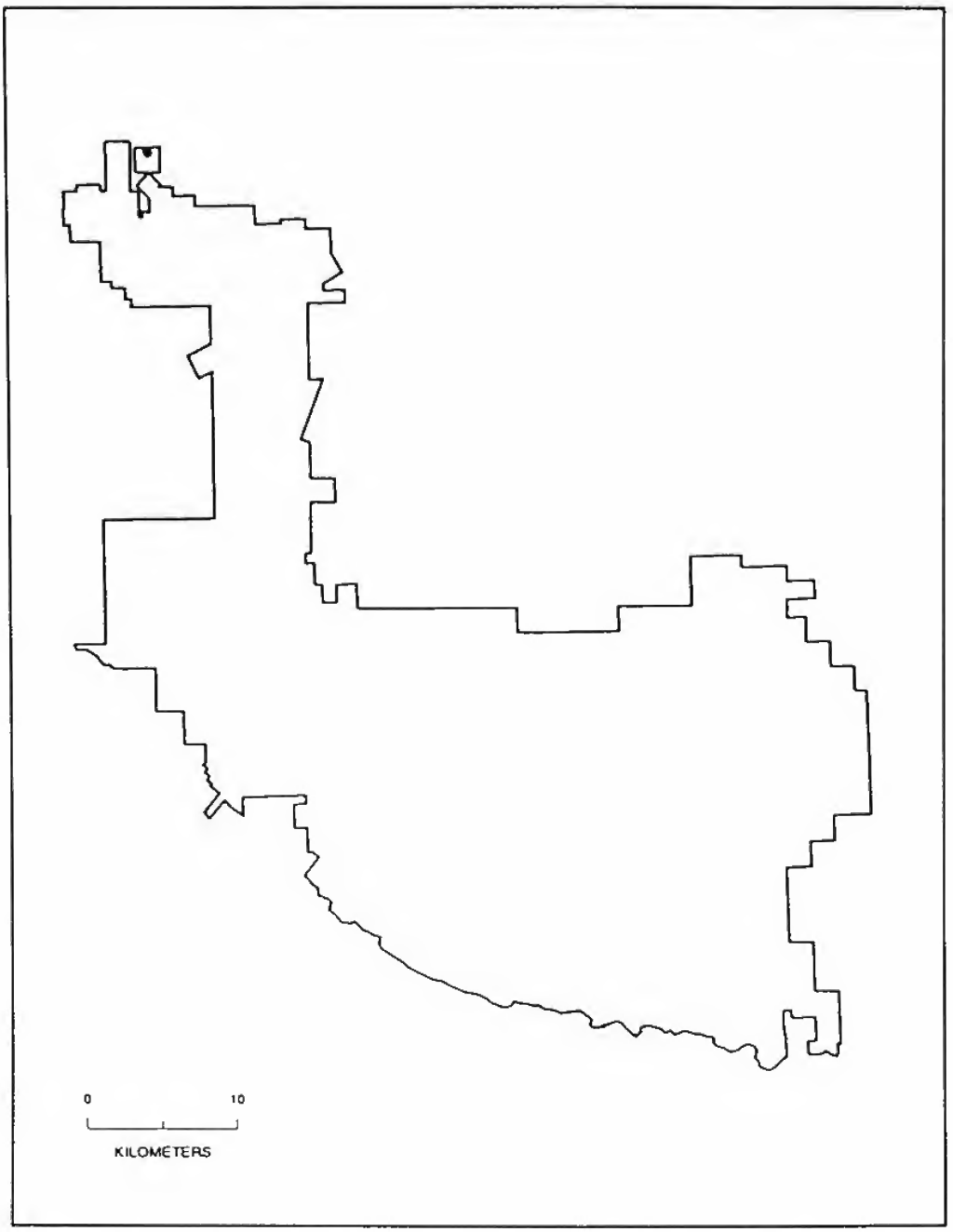

Figure 56. Localities of known specimens of *Mephitis mephitis* from Big Bend Ranch State Park, Texas.

Striped skunks primarily are nocturnal or crepuscular, but occasionally may be active during the day. Foraging activity typically begins around sunset. *M. mephitis* is omnivorous and is known to feed on a variety of food items (Godin, 1982). In the Trans-Pecos, its diet mostly consists of insects, with plant and vertebrate material comprising only a small percentage (Schmidly, 1977*a*). Other invertebrates, as well as carrion and garbage, also are consumed. This skunk usually hunts its animal prey by lying in wait or slowly stalking its prey (Godin, 1982).

The annual molt in *M. mephitis* begins around April, at which time the underfur starts to shed. Shedding of the guard hairs is delayed until July. At this time, replacement of both underfur and guard hairs oc-

curs. The molting process is complete by early September (Godin, 1982).

Other species of carnivores taken at the same localities as *M. mephitis* at BBRSP included *Bassariscus astutus*, *Procyon lotor*, and *Conepatus mesoleucus*.

No ectoparasites were noted on specimens of *M. mephitis* from BBRSP. Mites, ticks, lice, fleas, and botfly larvae previously have been reported to infest this skunk. Nematodes were collected from subcutaneous areas of several specimens at BBRSP. Additional endoparasites known to infect striped skunks include protozoans, acanthocephalans, trematodes, and cestodes. Microbes of medical importance harbored by this skunk include *Leptospira* sp. (leptospirosis), *Listeria monocytogenes* (listeriosis), *Francisella tularensis* (tularemia), *Aspergillus fumigatus* (farmer's lung), *Histoplasma capsulatum* (histoplasmosis), *Coxiella burnetii* (Q-fever), and the rabies virus (Godin, 1982).

Comments.— The subspecies of *M. mephitis* at BBRSP is *M. m. varians* Gray, 1837. The generic name (and specific epithet) *Mephitis* is derived from the Latin "mefitis," which translates to noxious exhalation (Stangl et al., 1993).

Specimens Examined (6).— Presidio Co.: BBRSP, UTM coordinates: 13 576785E 3296105N, 1; BBRSP, UTM coordinates: 13 576805E 3296248N, 2; BBRSP, UTM coordinates: 13 576699E 3296276N, 2; BBRSP, UTM coordinates: 13 576830E 3296165N, 1.

Conepatus mesoleucus (Lichtenstein, 1832)
Common Hog-nosed Skunk

Description.— *Conepatus mesoleucus* is a fairly large skunk with a dorsal pelage that is solid blackish brown with a single thick, solid white stripe extending from the crown of the head to the tail. The tail is long, bushy, and completely white. The snout of this skunk is noticeably long and the ears are small. All feet have five digits and bear long claws. The dental formula for *C. mesoleucus* is: i 3/3, c 1/1, p 2/3, m 1/2, total 32.

No measurements of adult *C. mesoleucus* specimens from BBRSP were obtained. Schmidly (1977*a*) lists the following means of external measurements for male and female hog-nosed skunks, respectively, from the Trans-Pecos: total length, 602, 551; length of tail vertebrae, 233, 215; length of hind foot, 68, 65; length of ear from notch, 27, 24. Davis and Schmidly (1994) list the range for the weight of this skunk as 1 to 2.7 kg. Males are larger than females (Davis and Schmidly, 1994).

Of other mammals known from BBRSP, *C. mesoleucus* might only be mistaken for *M. mephitis*, but the two can be identified easily as described in the previous account.

Distribution.— *C. mesoleucus* ranges from Central America, northward throughout Mexico, and into parts of the south-central and southwestern United States (Hall, 1981). In BBRSP, *C. mesoleucus* is known only from the Cienega area (Fig. 57).

Natural History.— One specimen of *C. mesoleucus* was taken during this study and an additional individual was sighted. This skunk reportedly is common in parts of the Trans-Pecos (Schmidly, 1977*a*), but is uncommon throughout most of its range (Davis and Schmidly, 1994), which appears to be the situation in BBRSP.

In the Trans-Pecos, *C. mesoleucus* is known to exploit a variety of habitats, including desert scrub, grasslands, and woodlands, but prefers rugged, rocky situations in mountainous areas (Schmidly, 1977*a*). Both encounters with hog-nosed skunks at BBRSP were in riparian woodland dominated by willow, false willow, and cottonwood.

During this study, *C. mesoleucus* was recorded in September and November. This skunk is active year

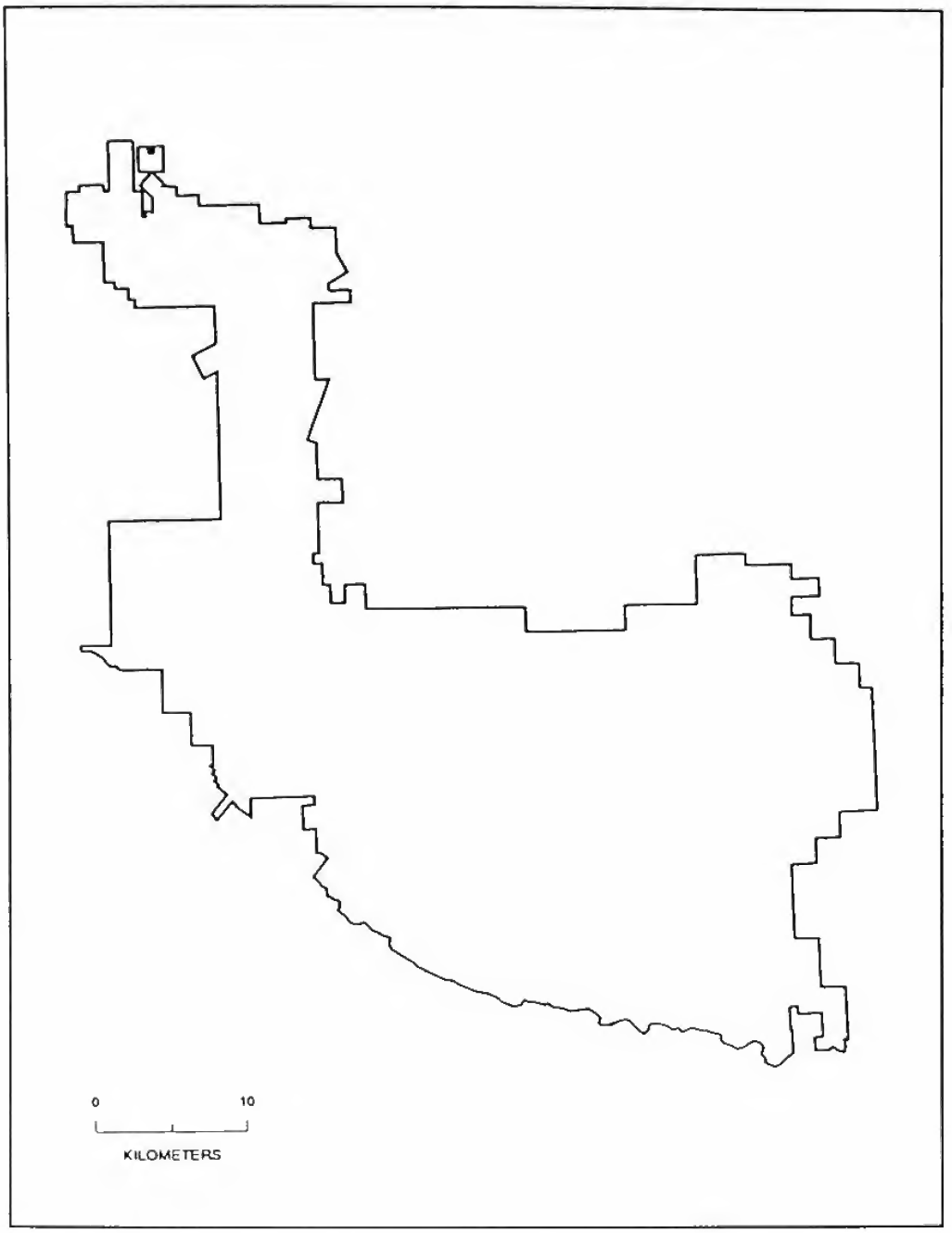

Figure 57. Localities of known specimens of *Conepatus mesoleucus* from Big Bend Ranch State Park, Texas.

round, although its activity patterns are known to vary by season (Davis and Schmidly, 1994).

The breeding season of *C. mesoleucus* begins in February (Davis and Schmidly, 1994). Following a gestation period of about two months, two to four (mean, 3) young are born (Schmidly, 1977*a*). At BBRSP, a subadult was noted on 6 September. Females may produce two litters a year (Davis and Schmidly, 1994).

Hog-nosed skunks primarily are nocturnal, but during winter may be more active during the daytime than at night. Typically they forage by overturning rocks and rooting in the soil in search of a variety of foods. Their diet varies by season, but insects seem to be the favorite food of these skunks. Other materials consumed include arachnids, small mammals, plant parts, reptiles, and mollusks (Davis and Schmidly, 1994).

Nothing has been reported on the annual molt of *C. mesoleucus*.

Other species of carnivores taken at the same locality as *C. mesoleucus* at BBRSP included *Bassariscus astutus*, *Procyon lotor*, and *Mephitis mephitis*.

No parasites were found in association with the specimen of *C. mesoleucus* from BBRSP. Howard and Marsh (1982) speculated that this skunk harbors mites, ticks, lice, and fleas. The only endoparasite reported from the common hog-nosed skunk is a subcutaneous nematode, *Filaria martis* (Tiner, 1946). Skunks in general have been implicated as reservoirs for the rabies virus (Howard and Marsh, 1982), but I know of no reports of infected *C. mesoleucus*.

Comments.— The subspecies of *C. mesoleucus* at BBRSP is *C. m. mearnsi* Merriam, 1902. The generic name *Conepatus* is derived from either the Greek "konis" and "patein," which translate to dust and walk, respectively, or the Aztec "conepatyl," which means digging skunk. The specific epithet *mesoleucus* is from the Greek "mesos" and "leukos," meaning middle and white, respectively (Stangl et al., 1993).

Specimens Examined (1).— Presidio Co.: BBRSP, UTM coordinates: 13 576783E 3296202N, 1.

Family Felidae (Cats)

Felis concolor (Linnaeus, 1771)
Mountain Lion

Description.— *Felis concolor* is a large cat with a uniform tan or grayish brown dorsal pelage. The tail is long and black-tipped, and the ears are short, rounded, and nontufted. Each forefoot has five digits, with the pollex raised high above the other toes. Each hind foot has four digits. All toes bear sharp, retractile claws. The dental formula for *F. concolor* is: i 3/3, c 1/1, p 3/2, m 1/1, total 28.

No linear measurements of *F. concolor* from BBRSP were obtained. Schmidly (1977*a*) reported the following external measurements for a male and a female, respectively, from the Trans-Pecos: total length, 2134, 1778; length of tail vertebrae, 876, 698; length of hind foot, 127, 89; length of ear from notch, 108, 76; weight, 50 kg, 36 kg. The mean weight (with extremes and standard deviation in parentheses) of 11 adult mountain lions from BBRSP reported by Pittman (1995) was 46.1 kg (28.1-63.5 kg, 14.9 kg). Hoffmeister (1986) reported specimens of *F. concolor* from southwestern North America with greatest length of skull measurements that ranged from 170.5 to 217.3. Males generally are larger than females (Currier, 1983).

F. concolor is not easily confused with any other species of mammal at BBRSP. It is distinguished easily from the other felids known from the park, *F. catus* and *L. rufus*, by its large size and uniform pale brown coloration.

Distribution.— *F. concolor* ranges from northern South America, northward throughout Central America, Mexico, the United States, and much of southern Canada (Hall, 1981), although it primarily is found in the western third of the United States and Canada (Currier, 1983). In BBRSP, a specimen is known from the Solitario (Fig. 58). In addition to the Solitario, lions have been trapped at Panther Mountain, Alamo Spring, Fresno Canyon, Arroyo Segundo, Las Burras, Botella Spring, Las Quevas, Alazan, Madera Canyon, and southeast of La Mota (Pittman, 1995). Mountain lion signs were sighted in the Los Alamos area and near Papalote Colorado. Given home ranges of up to 903 km^2 (Pittman, 1995), these cats undoubtedly range throughout the park.

Natural History.— No mountain lions were encountered during this study. However, in conjunction with another study conducted by Texas Parks and Wildlife personnel, 20 mountain lions have been trapped in the park between 22 January, 1993, and 21 April, 1995 (Pittman, 1985). These figures suggest that *F. concolor* is more abundant in the area than previously thought (Schmidly, 1977*a*).

Throughout its range, *F. concolor* is known to occupy a wide variety of ecological situations (Currier, 1983). In the Trans-Pecos, this cat reportedly is most

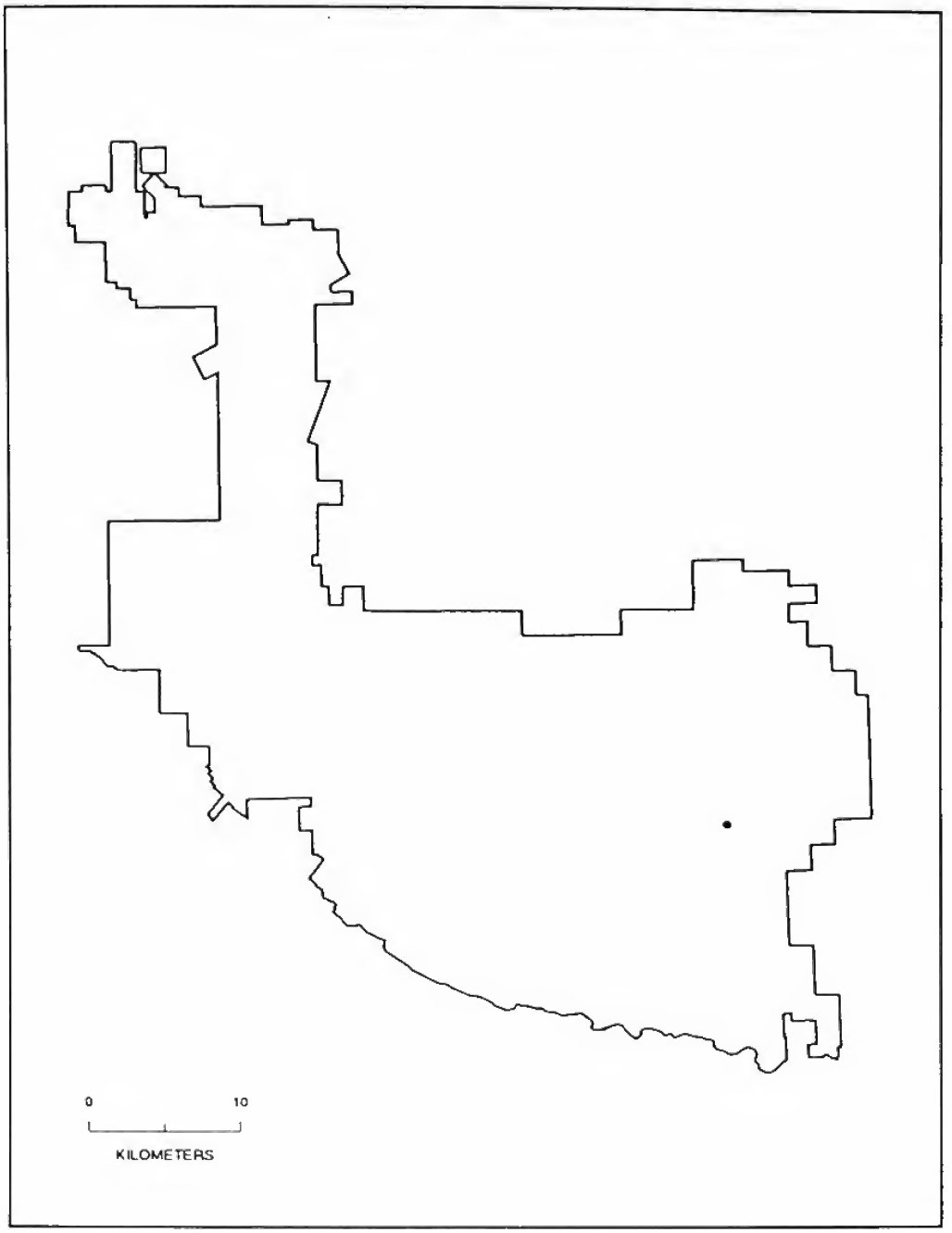

Figure 58. Localities of known specimens of *Felis concolor* from Big Bend Ranch State Park, Texas.

abundant in mountainous habitats (Schmidly, 1977*a*). At BBRSP, trapping records suggest that mountain lions have an affinity for canyonlands, especially those associated with water (Pittman, 1995).

Mountain lions have been captured at BBRSP from December through April, but active individuals were tracked throughout the year (Pittman, 1995).

Mountain lions may breed at any time during the year, but mating most often occurs between January and June. The gestation period ranges from 82 to 96 days, and most young are born between April and September (Currier, 1983). Pittman (1995) reported immature mountain lions at BBRSP on the following dates (with approximate age in parentheses): 4 February (2 to 4 weeks), 23 February (4 months), 24 February (2

months), and 21 April (6 months). Litter sizes range from one to six, but average 2.4 (Currier, 1983). Females typically breed every 18 to 24 months (McKinney, 1996).

F. concolor primarily is nocturnal or crepuscular (McKinney, 1996), but may be active at any time of day (Jones et al., 1983). This cat is an opportunistic carnivore that preys on a wide variety of animals. Throughout its range, deer are the most important prey item, but other large mammals (occasionally including domestic livestock), small mammals, birds, fish, and insects also may be consumed (Currier, 1983). Adult males may cannibalize cubs (Jones et al., 1983). At BBRSP, Pittman (1995) found mountain lions to feed on (in descending order of importance) collared peccaries, deer, and lagomorphs. *F. concolor* typically hunts large prey by stalking (McKinney, 1996). It approaches to within about 15 m of the prey, takes a few strides, then leaps on the victim's back. Rapid death of the prey is achieved by breaking the neck, crushing the esophagus, or puncturing the skull with a powerful bite. The kill is then dragged to an isolated area and fed upon. The remaining portion is covered with brush or other debris (but not buried), and often returned to later (Currier, 1983; McKinney, 1996).

Annual molting in *F. concolor* occurs in the spring.

Known ectoparasites of *F. concolor* include mites, ticks, lice, and fleas. Endoparasites include protozoans, trematodes, cestodes, and nematodes. Agents of human disease harbored by mountain lions include *Toxoplasma gondii* (toxoplasmosis), *Trichinella spiralis* (trichinosis), *Echinococcus granulosis* (hydatid disease), and the rabies virus (Dixon, 1982).

Comments.— The subspecies of *F. concolor* at BBRSP is *F. c. stanleyana* Goldman, 1938. The generic name *Felis* is derived from the Latin "feles," which translates to small carnivore. The specific epithet *concolor* is Latin for having the same color (Stangl et al., 1993). Some workers (Hemmer, 1978; Kratochvil, 1982) contend that *F. concolor* does not belong in the genus *Felis*, but rather in the genus *Puma*. Thus, *F. concolor* often is regarded as *P. concolor* (Wozencraft, 1993). I recognize the debate, but follow Jones et al. (1992) and retain *F. concolor* as the scientific name for the mountain lion.

Specimens Examined (1).— Presidio Co.: the Solitario, near Lower Shutup, 1 (SRSU).

Lynx rufus (Schreber, 1777)
Bobcat

Description.— *Lynx rufus* is a medium-sized cat with a dorsal pelage that is rufus brown or grayish with numerous dark spots. The tail is short (typically shorter than the hind foot), and the ears are medium-sized, pointed, and slightly tufted. The forefeet have five digits with the pollex raised high above the other toes, and the hind feet have four digits. Each toe bears a sharp, retractile claw. The dental formula for *L. rufus* is: i 3/3, c 1/1, p 2/2, m 1/, total 30.

No measurements of *L. rufus* from BBRSP were obtained. Schmidly (1977*a*) lists the following mean external measurements for males and a females, respectively, from the Trans-Pecos: total length, 870, 772; length of tail vertebrae, 146, 144; length of hind foot, 171, 158. Weight typically ranges from 5 to 9 kg (Davis and Schmidly, 1994). Hoffmeister (1986) reported specimens of *L. rufus* from Arizona with greatest length of skull measurements that ranged from 109.3 to 129.4. Males generally are larger than females (McCord and Cardoza, 1982).

Among other mammals known from BBRSP, *L. rufus* might be mistaken for *F. catus*, the feral cat, but can be differentiated easily on the basis of size and color pattern. The latter is larger and spotted, whereas the former is smaller and usually is not spotted. Also, *L. rufus* has two sets of upper premolars versus three sets in *F. catus*. Other than *F. catus*, the only other felid known from BBRSP is *F. concolor*. *L. rufus* can be distinguished from this felid as describerd in th previous account.

Distribution.— *L. rufus* ranges from Central Mexico, northward throughout most of the United States and much of southern Canada (McCord and Cardoza, 1982). In BBRSP, the bobcat has been documented only from the Cienega area (Fig. 59).

Natural History.— The only sign of *L. rufus* encountered during this study was a single set of tracks. Schmidly (1977*a*) reported the bobcat as fairly common throughout the Trans-Pecos, but Pittman (1995) estimated the density of *L. rufus* at BBRSP to be extremely low as compared to estimates nationwide (McCord and Cardoza, 1982).

L. rufus is known to exploit a variety of habitats (McCord and Cardoza, 1982), but in the Trans-Pecos seems to prefer rocky canyons (Schmidly, 1977*a*). The only bobcat sign noted at BBRSP during this study was in a dry wash traversing desert scrub near riparian woodland.

During this study, *L. rufus* was noted only in November. This cat is active year round, although patterns in daily activity may vary by season (McCord and Cardoza, 1982).

The breeding season of bobcats begins in February and probably continues through April. Following a gestation period of about 62 days, one to eight (mean, 2-4) kittens are born in late spring or early summer. A single litter is produced annually, although there is some speculation that, in rare instances, females may give birth to two litters a year (McCord and Cardoza, 1982).

L. rufus has been described as both a crepuscular (McCord and Cardoza, 1982) and a nocturnal hunter (Jones et al., 1983). In either case, it seldom is active during the day. As are many carnivores, the bobcat is an opportunistic hunter, and will take almost any prey that is available. Favorite prey items of this cat that occur at BBRSP include desert cottontails, black-tailed jackrabbits, and woodrats. Occasionally this cat will kill and consume young deer and pronghorn (McCord and Cardoza, 1982). Bobcats typically capture prey by sitting motionless and waiting for its victim to wander within range of a single bound. The cat then pounces on the prey and subdues it with its sharp claws and canine teeth (Jones et al., 1983).

A single annual molt in *F. rufus* begins in fall and is complete by late fall or early winter. No molt occurs in spring as the summer pelage actually is worn winter pelage (Jones et al., 1983).

Ectoparasites known to infest *L. rufus* include mites, lice, and fleas. Internal parasites documented to infect this cat include trematodes, cestodes, and nematodes. Medically important organisms associated with bobcats include *Leptospira* sp. (leptospirosis), *Brucella* sp. (brucellosis), *Salmonella* sp. (enteritis), *Toxoplasma gondii* (toxoplasmosis), *Pasturella multocida* (septicemia), and the rabies virus (McCord and Cardoza, 1982).

Comments.— The subspecies of *L. rufus* at BBRSP is *L. r. texensis* J. A. Allen, 1895. The generic name *Lynx* is Greek for lynx. The specific epithet *rufus* is Latin for red (Stangl et al., 1993). Some workers consider all North American felids to belong to the genus *Felis*. I acknowledge this controversy, but follow Jones et al. (1992) and retain *Lynx* as a distinct genus.

Specimens Examined (1).— Presidio Co.: BBRSP, Cienega Ranch, 1 (SRSU).

ORDER ARTIODACTYLA—EVEN-TOED UNGULATES

Family Dicotylidae (Peccaries)

Tayassu tajacu (Linnaeus, 1758)
Collared Peccary

Description.— *Tayassu tajacu* is a medium-sized piglike mammal with a long, coarse, dorsal pelage that is grizzled grayish black in color. A pale, whitish collar is present about the shoulders. The snout is short and piglike. The tail is short and the ears are small. The feet are hoofed; the forefeet with four toes and the hind feet with only three. The canines are large, straight, and tusklike. The dental formula for *T. tajacu* is: i 2/3, c 1/1, p 3/3, m 3/3, total 38.

No external measurements of *T. tajacu* from BBRSP were obtained. Schmidly (1977*a*) lists the following mean external measurements for a single speci-

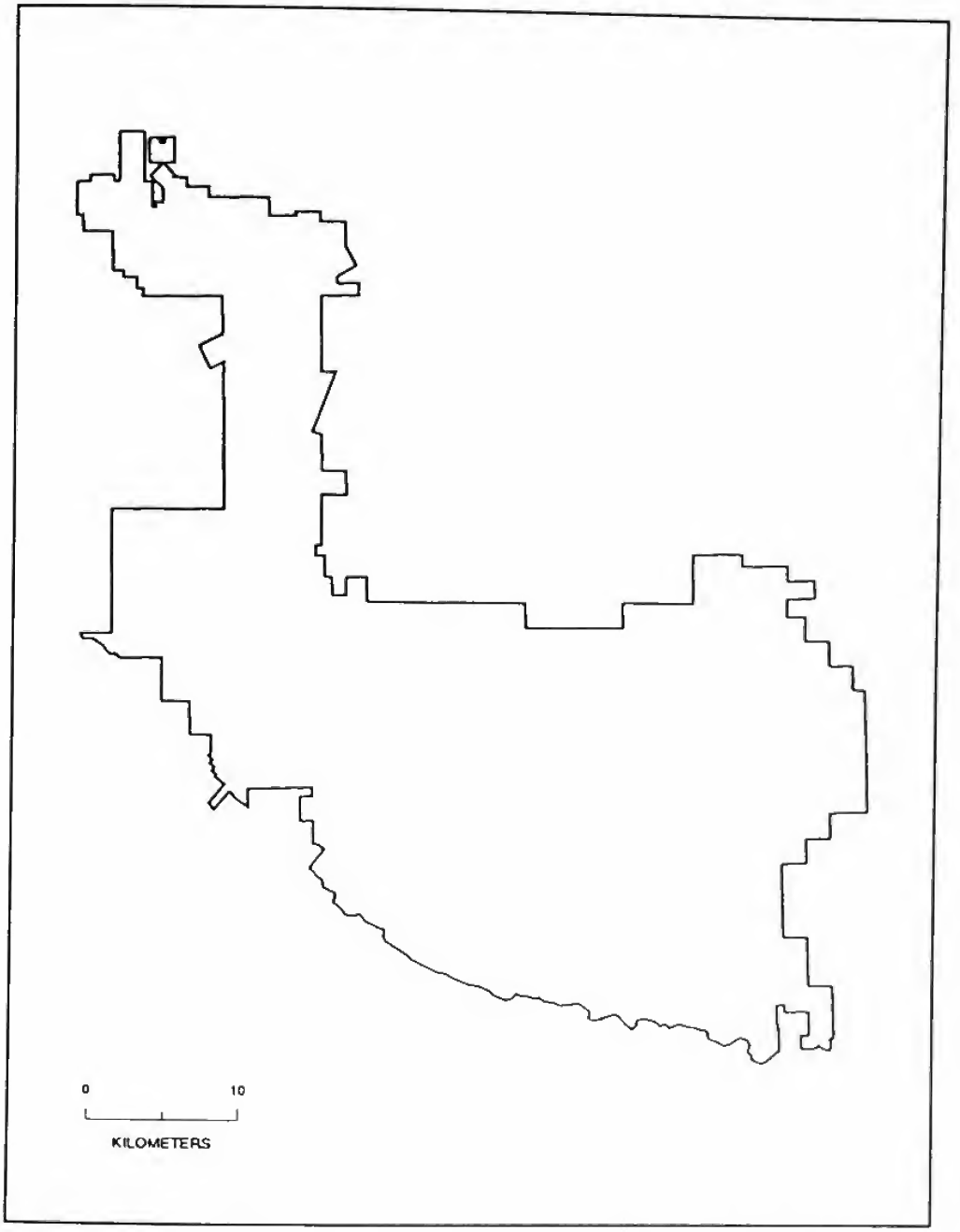

Figure 59. Localities of known specimens of *Lynx rufus* from Big Bend Ranch State Park, Texas.

men from the Trans-Pecos: total length, 940; length of tail vertebrae, 55; length of hind foot, 180; length of ear from notch, 100. Davis and Schmidly (1994) reported the weight to range from 13 to 25 kg. The greatest length of skull measurement of a single specimen from BBRSP is 216.5. No sexual dimorphism has been documented in collared peccaries (Bissonette, 1982).

The only other mammal at BBRSP that *T. tajacu* might be confused with is *Sus scrofa*, the feral pig. These two artiodactyls can be distinguished as follows. *T. tajacu* has a pale collar about its shoulders, three toes on each hind foot, upper canines that are directed downward, and two sets of upper incisors and three sets of upper premolars. In contrast, *S. scrofa* lacks a collar around the shoulders, has four toes on each hind foot, has upper canines that curve upward and outward, and three and four sets of upper incisors and premolars, respectively.

Distribution.— The range of *T. tajacu* extends from Central America, northward throughout much of Mexico, and into Texas, southern New Mexico, and Arizona (Hall, 1981). In BBRSP, specimens of collared peccaries are known from the Cienega Mountains, Sauceda, and Los Alamos areas (Fig. 60). Furthermore, *T. tajacu* was sighted throughout the park.

Natural History.— Six specimens of *T. tajacu* were acquired during this study, and countless individuals, as well as considerable peccary sign, were noted. Based on these observations, collared peccaries should be regarded as common in BBRSP.

Collared peccaries reportedly favor brushy habitats where prickly pear cactus is abundant (Davis and Schmidly, 1994). At BBRSP, these mammals were encountered most frequently in such areas, but also were observed in grassland and riparian habitats. In addition, *T. tajacu* was common near human dwellings.

Collared peccaries are active throughout the year, and were observed as such at BBRSP. They do, however, exhibit seasonal fluctuations in activity patterns (Bissonette, 1982).

T. tajacu is the only wild ungulate in the New World that breeds throughout the year (Davis and Schmidly, 1994). Typically, only the dominant (alpha) male mates with estrous females. Following a gestation period of about 145 days, two to five young are born. Typical litters consist of only two young, and in larger litters, seldom do more than two survive. Females usually breed once a year, but are capable of multiple births during a given year (Bissonette, 1982). At BBRSP, juveniles were noted in the population in March.

The daily activity patterns of *T. tajacu* are known to vary by season. During summer, peccaries mostly are nocturnal and crepuscular, whereas they are more diurnal in autumn and winter. This ungulate is social, and frequently was observed foraging in herds. The bulk of the peccary's diet consists of plant material. Little or no animal material usually is consumed. Principal food items include the fleshy parts of prickly pear cactus and lechuguilla, as well as various forbs, grasses, seeds, and nuts. In addition to providing nutrition, prickly pear cactus apparently supplies most of the water requirements (Bissonette, 1982). Peccaries do not typically root in the ground for food as do pigs. Rather they push around surface soil in an effort to turn up pieces of cactus and other plant material (Davis and Schmidly, 1994). At BBRSP, peccaries frequently were observed feeding on garden fruits, horse feed, and garbage near human habitations.

Seasonal molting in *T. tajacu* apparently occurs by summer as hairs begin to fall off and bristles break at the tips. This results in a paler color, which allows for greater reflectance and less absorption of solar radiation. By winter, the pelage again becomes longer and darker (Sowls, 1984).

Ectoparasites previously reported from *T. tajacu* include mites, biting lice, sucking lice, and fleas. Endoparasites include protozoans, trematodes, cestodes, and nematodes (Sowls, 1984).

Comments.— The subspecies of *T. tajacu* at BBRSP is *T. t. angulatus* (Cope, 1889). The generic name *Tayassu* and the specific epithet *tajacu* are derived from the Tupi "taya" and "cu," which translate to farinaceous tuberous root and eat, respectively (Stangl et al., 1993).

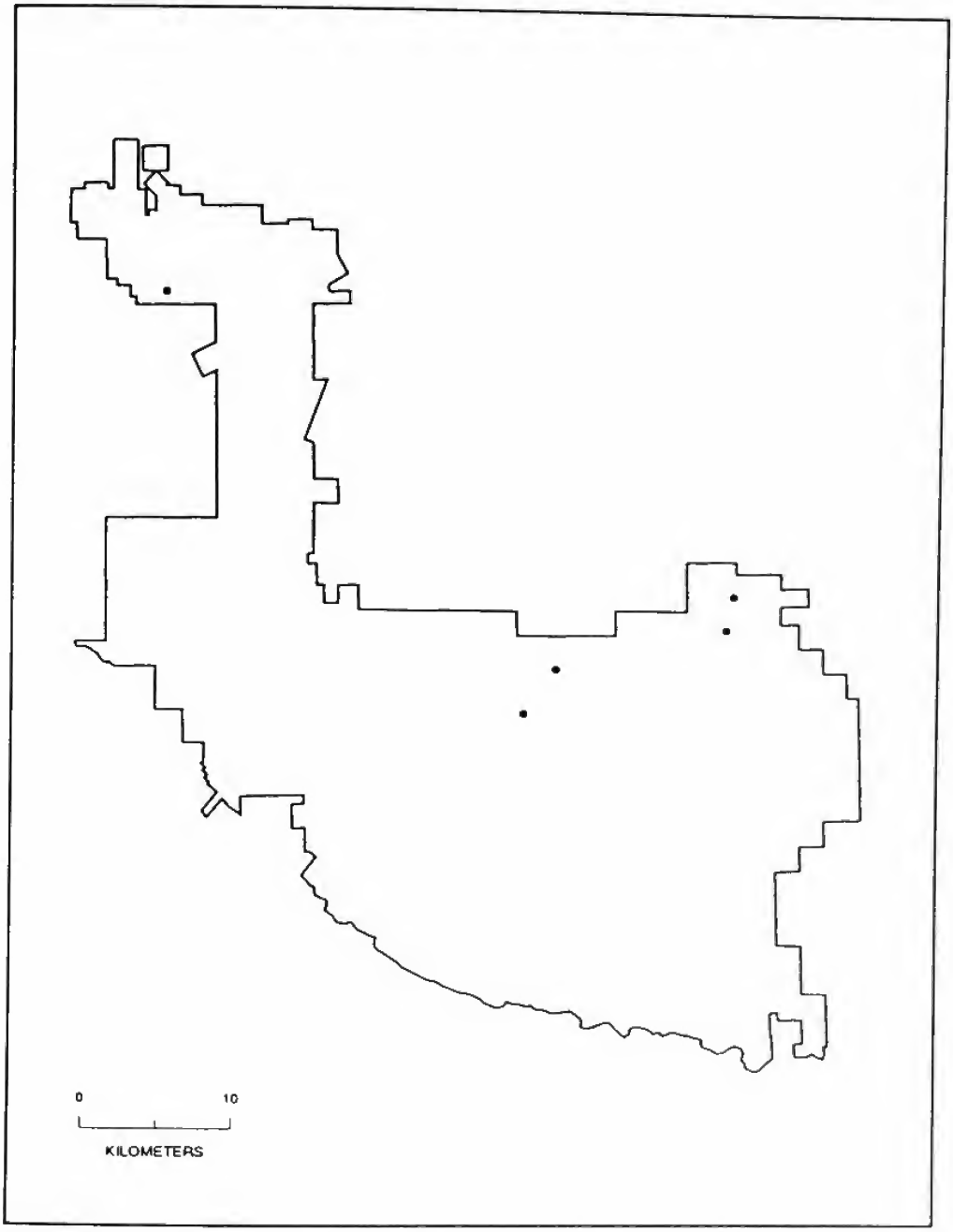

Figure 60. Localities of known specimens of *Tayassu tajacu* from Big Bend Ranch State Park, Texas.

Specimens Examined (6).— Presidio Co.: BBRSP, UTM coordinates: 13 601203E 3260197N, 1; BBRSP, UTM coordinates: 13 603273E 3263098N, 1; BBRSP, UTM coordinates: 13 614458E 3265716N, 1; BBRSP, UTM coordinates: 13 577589E 3287154N, 1; BBRSP, UTM coordinates: 13 614933E 3267912N, 2.

Family Cervidae (Deer)

***Odocoileus hemionus* (Rafinesque, 1817)**
Mule Deer

Description.— *Odocoileus hemionus* is a medium to large deer with a grayish tan dorsal pelage mixed

with black. The tail is short, white or buff above, and tipped in black. The ears are noticeably large. Dichotomously branched antlers are present in males (rarely in females). Each foot has four toes, but only digits three and four are hoofed, the lateral toes being greatly reduced. The dental formula for *O. hemionus* is: i 0/3, c 0/1, p 3/3, m 3/3, total 32.

No external measurements of *O. hemionus* from BBRSP were obtained. Schmidly (1977*a*) presented the following ranges of external measurements for males and females, respectively, from the Trans-Pecos: total length, 1370-1830, 1160-1800; length of tail vertebrae, 106-230, 115-200; length of hind foot, 330-585, 325-475; length of ear from crown, 118-250, 118-243. Davis and Schmidly (1994) reported the weight of *O. hemionus* to range from 57 to 102 kg, although large individuals have been known to weigh as much as 112.3 kg (Anderson and Wallmo, 1984). The greatest length of skull measurement of a male specimen from BBRSP is 301.5. Males are considerably larger than females (Anderson and Wallmo, 1984).

O. hemionus can be mistaken easily for *O. virginianus*, the only other cervid at BBRSP. However, these two deer can be separated on the basis of tail appearance, antler structure, ear size, and cranial morphology. *O. hemionus* has a black-tipped tail, dichotomously branched antlers, large ears, and a deep preorbital pit. On the other hand, *O. virginianus* has a tail that is brown above with white fringe, antlers with a single main beam, smaller ears, and a shallow preorbital pit.

Distribution.— *O. hemionus* ranges from northern Mexico, northward throughout the western United States and Canada (Anderson and Wallmo, 1984). Specimens of mule deer are known from scattered areas in BBRSP (Fig. 61). In addition, *O. hemionus* was sighted throughout the park.

Natural History.— During this study, eight specimens of *O. hemionus* were collected at BBRSP. In addition, numerous individuals were sighted, indicating that this deer is fairly common at BBRSP. Mule deer usually do not occur in high densities, especially in open areas such as those typical of much of BBRSP (Mackie et al., 1982). Pittman (1995) estimated mule deer densities to be as high as 1.4 individuals per km^2 at BBRSP. Throughout the range of *O. hemionus*, open areas usually support less than two deer per km^2, and often less than 0.5 deer per km^2 (Mackie et al., 1982). These figures suggest that the mule deer population at BBRSP is relatively healthy.

O. hemionus is highly adapted, and may utilize a wide variety of habitats (Mackie et al., 1982). In the Trans-Pecos, this deer occupies almost all habitat types, but seems to prefer barren foothills and desert ranges 900 to 1500 m in elevation (Schmidly, 1977*a*). At BBRSP mule deer were encountered most often in such habitats.

During this study, mule deer were encountered throughout the year. This deer is active year round, but often uses different parts of its home range at various times of the year (Mackie et al., 1982).

O. hemionus is polygynous, but practices a tending-bond type breeding system rather than a harem-breeding system (Anderson and Wallmo, 1984). The breeding period occurs in autumn or early winter. Following a gestation period of about 203 days, young are born in summer. Typically, litters consist of two fawns but one is not uncommon; triplets are rare (Mackie et al., 1982). At BBRSP, a gravid female was examined on 13 May. Only a single fetus was noted (crown-rump length, 1300); however, the deer was a fresh mountain lion kill and the one fetus was found a few meters from the carcass. It is conceivable that the doe was carrying more than one fetus at the time of the kill.

O. hemionus typically is crepuscular (Jones et al., 1983), but at BBRSP often was observed at night and during the day as well. This deer browses on several types of woody plants, but also is known to graze on grasses and forbs (Jones et al., 1983). Yucca, sumac, lechuguilla, and grama grasses were typical foods eaten by mule deer in the nearby Sierra Vieja (Anderson, 1949), and are likely to be consumed at BBRSP as well.

Adult mule deer exhibit two annual molts. In late spring, the winter coat is replaced by a reddish summer pelage. Then in early fall, a dark gray winter pelage with woolly underfur replaces the summer coat (Mackie et al., 1982).

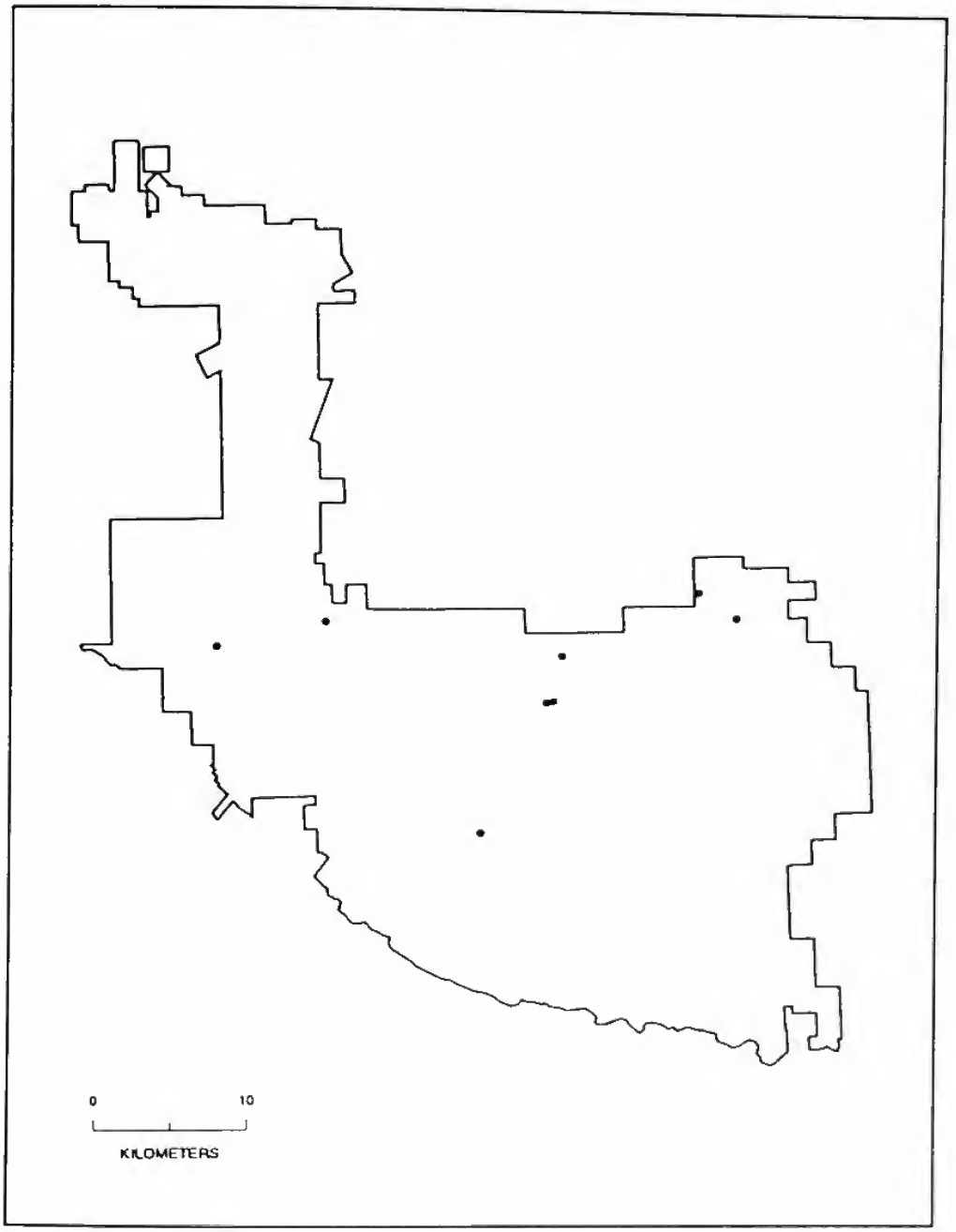

Figure 61. Localities of known specimens of *Odocoileus hemionus* from Big Bend Ranch State Park, Texas.

No parasites were noticed in association with *O. hemionus* from BBRSP. Ectoparasites reported previously from mule deer include ticks, lice, and fleas. Endoparasites include protozoans, trematodes, cestodes, and nematodes. Organisms of medical significance that have been associated with *O. hemionus* include *Pasteurella multocida* (septicemia), *Brucella* sp. (brucellosis), and *Bacillus anthracis* (athrax; Anderson and Wallmo, 1984). In addition, mule deer are known to harbor *Ixodes pacificus* (Anderson and Wallmo, 1984), a tick known to transmit Lyme disease (Benach et al., 1990).

Comments.— The subspecies of *O. hemionus* at BBRSP is *O. h. crooki* (Mearns, 1897). The generic name *Odocoileus* is derived from the Greek "odous"

and "koilos," which translate to tooth and hollow, respectively. The specific epithet *hemionus* is from the Greek "hemionos" meaning half-ass (Stangl et al., 1993).

Specimens Examined (8).— Presidio Co.: BBRSP, UTM coordinates: 13 580522E 3264400N, 1; BBRSP, UTM coordinates: 13 587667E 3266036N, 1; BBRSP, UTM coordinates: 13 597663E 3252298N, 1; BBRSP, UTM coordinates: 13 602053E 3260740N, 1; BBRSP, UTM coordinates: 13 602506E 3260843N, 1; BBRSP, UTM coordinates: 13 603101E 3263765N, 1; BBRSP, UTM coordinates: 13 612120E 3267800N, 1; BBRSP, UTM coordinates: 13 614618E 3266110N, 1.

Odocoileus virginianus (Zimmermann, 1780)
White-tailed Deer

Description.— *Odocoileus virginianus* is a small to medium sized deer with a dorsal pelage that ranges from reddish tan to grayish brown in color. The tail is short, brown above, fringed in white, and white below. The ears are relatively short. Males (rarely females) possess antlers that have a single main beam from which tines project vertically. The feet have four toes; the two middle digits are hoofed and the two lateral toes are reduced. The dental formula for *O. virginianus* is: i 0/3, c 0/1, p 3/3, m 3/3, total 32.

No external or cranial measurements of *O. virginianus* from BBRSP were obtained. Krausman and Ables (1981) presented the following external and cranial measurements for a white-tailed deer from the Big Bend area: total length, 1512; length of tail vertebrae, 214; length of hind foot, 403, greatest length of skull, 242.3. The length of ear of white-tails in general typically ranges from 139 to 228 (Schmidly, 1983). The weight of males and females average 47 kg and 30 kg, respectively. Males are larger than females (Krausman and Ables, 1981).

O. virginianus might be mistaken for *O. hemionus*, but these two species of deer can be distinguished as described in the previous account.

Distribution.— *O. virginianus* ranges from northern South America, northward throughout Central America, Mexico, and most of the United States and southern Canada (Smith, 1991). No specimens of white-tailed deer are known from BBRSP; however, this species has been sighted along the Rio Grande.

Natural History.— No specimens of *O. virginianus* were collected during this study, and no individuals were sighted by me. This deer is known from BBRSP only on the basis of rare sightings by park naturalist David Alloway. *O. virginianus* probably is not a regular inhabitant of the park, but rather wanders into the area on rare occasions.

O. virginianus is known to utilize a wide variety of habitats (Smith, 1991), but in the Big Bend region, this deer reportedly favors the high elevations of mountainous areas (Schmidly, 1977*a*). The lack of this topography at BBRSP probably accounts for the transient status of white-tailed deer at the park.

O. virginianus is active year round, but its use of habitat may vary by season (Hesselton and Hesselton, 1982).

Throughout its range, white-tailed deer typically breed in the fall (Hesselton and Hesselton, 1982). However, peak reproductive activity in the Big Bend area runs from mid-December through mid-January. Following a gestation period of about 201 days, fawns are born in July and August (Krausman and Ables, 1981). Almost all litters consist of twins (Hesselton and Hesselton, 1982), but litter sizes range from one to three (Smith, 1991).

White-tailed deer are primarily crepuscular, but may be active at any time of day (Krausman and Ables, 1981). The specific diet of this deer varies by location and season (Smith, 1991). In the Big Bend region, it is known to feed on browse, forbs, succulents, and grasses (Krausman and Ables, 1981).

O. virginianus molts two times a year. The summer coat, which is acquired in early spring, is short, thin, and reddish in color. In late summer or early fall, the summer pelage is replaced by a longer, thicker, and darker winter coat (Hesselton and Hesselton, 1982).

Ectoparasites documented to infest *O. virginianus* include ticks, lice, and botfly larvae. Endoparasites include protozoans, trematodes, cestodes, and nematodes. *O. virginianus* is afflicted by several viral, bacterial, and fungal diseases. Those that are important from a medical perspective include *Bacillus anthracis* (anthrax), *Brucella* sp. (brucellosis), and *Mycobacterium tuberculosis* (tuberculosis; Hesselton and Hesselton, 1982).

Comments.— The subspecies of *O. virginianus* at BBRSP is *O. v. carminis* (Goldman and Kellog, 1940). See the account on *Odocoileus hemionus* for the etymology of the generic name. The specific epithet *virginianus* refers to of Virginia (Stangl et al., 1993).

Specimens Examined (0).

Family Antilocapridae (Pronghorn)

***Antilocapra americana* (Ord, 1815)**
Pronghorn

Description.— *Antilocapra americana* is a small, antelope-like mammal with a dorsal pelage that primarily is tan with white sides, rump patches, chest, throat bands, and cheeks. Dark markings are present about the head, chin, and neck. The tail is short and the ears are moderate in size. Both sexes may possess horns from which the horny sheaths are shed annually. The horns of males are long and pronged, whereas those of females are shorter and usually not pronged. Each foot has only two toes; lateral toes are absent. The dental formula for *A. americana* is: i 0/3, c 0/1, p 3/3, m 3/3, total 32.

No external or cranial measurements of *A. americana* from BBRSP were obtained. Schmidly (1977*a*) reported the following mean external measurements of one male and one female from Presidio County: total length, 1325; length of tail vertebrae, 62; length of hind foot, 388; length of ear, 149. Members of the subspecies found at BBRSP average about 40 kg in weight (O'Gara, 1978). Females are somewhat smaller than males (Kitchen and O'Gara, 1982).

The size, color pattern, and presence and morphology of horns make it difficult to confuse *A. americana* with any other species of mammal known from BBRSP.

Distribution.— Populations of *A. americana* are scattered from Central Mexico, northward throughout much of the western United States and parts of southern Canada (O'Gara, 1978). No specimens of pronghorns are known from BBRSP; however, this species has been sighted north of the Solitario near the northeastern park boundary. In addition, pronghorns were observed outside park boundaries in the Cienega Mountains area.

Natural History.— *A. americana* was not encountered in BBRSP during this study. It is known from the park only on the basis of an observation reported to me by David Riskind of the Texas Parks and Wildlife Department. Pronghorns are fairly common just north of BBRSP, but apparently are extremely rare in the park.

A. americana typically inhabits grasslands and shrublands with low, rolling topography, a combination of grasses, forbs, and shrubs for foraging, and an annual precipitation of 25 to 35 cm (Kitchen and O'Gara, 1982). There are some areas of BBRSP that fulfill the first two requirements, but the precipitation rate at the park is far below what this ungulate typically requires. Individuals that occur in BBRSP probably wander in from the more optimal habitats to the north.

Pronghorns are active throughout the year, although daily activity may vary by season (Kitchen and O'Gara, 1982).

The early literature indicates that pronghorns are a harem-breeding mammal, but later studies suggest a territorial-breeding system (Kitchen and O'Gara, 1982). The breeding season of *A. americana* varies by geography (Kitchen and O'Gara, 1982), but in the Trans-Pecos is known to occur from late August through early October. Following a gestation period of about seven months, parturition occurs from early April to late May. Typically twins are produced, but litter sizes range from one to three (Schmidly, 1977*a*).

A. americana is known to be nocturnal, diurnal, or crepuscular, be seems most often to prefer the latter. Foods consumed by this species vary geographically

(Kitchen and O'Gara, 1982), but in the Trans-Pecos, it is known to forage on such plants as bitterweed, cutleaf daisy, side-oats grama, blue grama, dalea, eriogonum, deer vetch, paper flower, coneflower, and woolly senecio (Schmidly, 1977*a*).

Annual molt in *A. americana* begins in late winter or early spring. By August, the old pelage is replaced entirely with new, shorter pelage. The hairs of this new pelage lengthen with the approach of winter (Kitchen and O'Gara, 1982).

Ectoparasites reported to infest *A. americana* include ticks and hippoboscid flies. Internal parasites include protozoans, trematodes, cestodes, and nematodes. Diseases known to afflict pronghorns are epizootic hemorrhagic disease, bluetongue, necrobacillus, vibriosis, actinomycosis, and keratitus (Kitchen and O'Gara, 1982).

Comments.— The subspecies of *A. americana* at BBRSP is *A. a. mexicana* Merriam, 1901. The generic name *Antilocapra* is derived from the Greek "antholops" and the Latin "capra," which translate to beast with elongated horns and she-goat, respectively. The specific epithet *americana* refers to of (North) America (Stangl et al., 1993).

Specimens Examined (0).

Nondomestic Introduced Species

Nondomestic introduced mammals at BBRSP include two species of bovids that are not indigenous to the park, but are known to occur there as free-ranging populations due to introduction into the area by humans. These two mammals are treated in the following abbreviated accounts.

Capra ibex
Ibex

Capra ibex is a large, reddish-tan to dark brown goat. Both sexes possess horns, with those of males being large (700 to 1400) and those of females considerably smaller (150 to 380). The horns of males are scimitar-shaped with a flat anterior surface that is broken by prominent transverse ridges. Horns of females are more slender. Both sexes have a conspicuous woolly beard on the chin. No specimens from BBRSP were measured, but for the species in general, the total length ranges from 1250 to 1900, and the tail length ranges from 100 to 200. Weights range from 35 to 150 kg (Nowak, 1991).

The characteristics of the horns and the presence of a beard distinguish the ibex from other ungulates at BBRSP.

C. ibex is a native inhabitant of the European Alps and the mountains of India, Pakistan, Afghanistan, and northern Africa (Nowak, 1991). In the early 1970s, this goat was introduced into BBRSP for sport hunting. I did not encounter *C. ibex* during this study, but during the 1994 hunting season four individuals were taken in the park (Armendariz, pers. comm., 1996).

The ibex is known to occur in open montane areas up to 6700 m (Nowak, 1991). It rarely is encountered in BBRSP, partially due the low number of individuals that occurs there, and partially because of this goat's attraction to rough, mountainous topography (Nowak, 1991).

Ammotragus lervia
Aoudad

The aoudad, or Barbary sheep, is a robust, rufous-tawny colored bovid (Gray and Simpson, 1980) that shares characters with both goats and sheep (Manwell and Baker, 1977). Both sexes possess large, moderately long (up to 840), spiraled horns that project inward, or inward and downward. Shallow, uniform sulci and periodic growth rings may be present, but prominent transverse ridges are lacking (Gray and Simpson, 1980). A long ventral mane that extends down the neck to the chest is present (Nowak, 1991). In adults, this fringe of hair bifurcates and descends down the forelimbs forming chaps. No specimens from BBRSP were measured, but large males taken in New Mexico had total lengths up to 1960, and weights up to 145 kg. Tail lengths of this species range from 175 to 205 (Gray and Simpson, 1980).

A. lervia can be distinguished easily from other ungulates at BBRSP by the presence of its unique horns, long ventral mane, and foreleg chaps.

The aoudad is a native inhabitant of North Africa (Gray and Simpson, 1980), but for the purpose of sport hunting, was introduced into the United States during the early 1900s (Nowak, 1991). Several aoudads were released into the BBRSP area in the early 1970s (Armendariz, pers. comm., 1996). Annual public hunts for aoudads were held each year during the course of this study, but no individuals were taken. No specimens were collected during this study, but one individual was sighted in the Sauceda area.

This species is known to occur in arid to semiarid regions from sea level to up to 1929 m in elevation (Gray and Simpson, 1980), and therefore might be found nearly anywhere in BBRSP. However, it is not commonly encountered in the park, probably because only a small population resides there and because of the animal's affinity for rough, rocky situations, and its ability to conceal itself by remaining motionless when threatened (Nowak, 1991).

A major concern regarding the aoudad's presence in BBRSP arises when considering the reintroduction of bighorn sheep. It has not been documented, but there is speculation that where the two species might occur sympatrically, the aoudad would out compete the bighorn for limited, shared resources (Barrett, 1967; Simpson et al., 1978).

Domestic Species

Seven species of mammals that have been domesticated by humans and are known to occur in BBRSP are discussed in the abbreviated accounts below. Scientific and vernacular names follow Nowak (1991).

Canis familiaris
Domestic Dog

Domestic dogs may take on a variety of sizes, shapes, and colors. Measurements for all breeds of domestic dogs combined range as follows: total length, 360 to 1450; tail length, 130 to 510; weight, 1 to 79 kg (Anonymous, 1981). At BBRSP, domestic dogs potentially may be confused with coyotes, kit foxes, or gray foxes. For distinguishing characters, see the accounts on *Canis latrans*, *Vulpes velox*, and *Urocyon cinereoargenteus*.

Free-ranging dogs are not common in BBRSP, but may occur anywhere in the park, especially in the Rio Grande Corridor. They are known to subsist on a variety of foods, including deer, livestock, rodents, ground-nesting birds, carrion, and garbage. In addition, unrestrained pet dogs may be encountered, mostly in the vicinity of Sauceda.

Felis catus
Domestic Cat

Depending on the breed, feral domestic cats may present a variety of morphotypes, but typically have the appearance of pet cats. The average total and tail lengths for several breeds combined are 460 and 300, respectively (Anonymous, 1981). The only mammal known to occur in BBRSP that *F. catus* might be mistaken for is the bobcat. See the account on the bobcat for a comparison of characters.

Free-ranging cats were noted in BBRSP only on rare occasions near human dwellings, but may be encountered anywhere in the park, especially in the Rio Grande Corridor. They are carnivorous and may cause considerable damage to native wildlife, particularly songbirds (Lowery, 1974). Also, unrestrained pet cats are present in the Sauceda area.

Equus caballus
Domestic Horse

Domestic horses vary greatly in appearance. They have a wide range of color patterns and sizes. Size usually is large with the average height at the shoulder about 1550, and average weight about 530 kg (Nowak, 1991). The domestic horse might be mistaken for the burro. Externally, these vary in that the horse is larger and usually has a mane of long hairs that hang down, whereas the burro is smaller and has a mane that usually is directed upright. In addition, the burro usually is grayish with a dark cross on its shoulders. Horses are variable in color, but dark crosses on the shoulders usu-

ally are absent. Horses also may be mistaken for mules, which also occur at BBRSP. These animals are hybrids between *E. caballus* and *E. asinus* (see the following account). Mules can be identified by their variable coloration, absence of a dark cross, and presence of long ears (Anderson, 1972).

No feral populations of the domestic horse occur in BBRSP. However, approximately 10 to 12 individuals are maintained at the park for use by park personnel. These animals often are allowed to roam free while grazing. They most frequently are seen in the grassy pastures near Sauceda.

Equus asinus
Burro

The burro is horse-like in appearance, but smaller. It usually is gray in color, and often sports a dark cross-shaped pattern on its shoulders. The end of its muzzle, the rings about its eyes, and the hairs inside its ears usually are paler in color than the rest of the head (Anderson, 1972). Average measurements of individuals taken in the wild are: total length, 2450; tail length, 450, height at shoulder, 1250; weight, 250 kg. The burro may be confused with the horse or mule, but can be distinguished as described in the previous account.

Feral populations of *E. asinus* are common in the southwestern United States, but appear to be rare in BBRSP, where only a single individual was noted. It was sighted from a helicopter in desert scrub in the area between Alamito Creek and the Cienega Mountains. Wild burros are known to cause tremendous damage to the environment. Furthermore, this mammal is known to adversely affect desert bighorn populations via competition (Nowak, 1991). The presence of burros in BBRSP should be a concern given the plan to reintroduce the bighorn into the park.

Sus scrofa
Domestic Pig

Sus scrofa may present a variety of appearances, but typically is large and squat in stature. The pelage is scant, usually consisting of only some stiff bristles and fine fur (Nowak, 1991). The fur is coarser and denser in feral individuals (Sweeney and Sweeney, 1982). Total length ranges from 1200 to 2100 and tail length is about 300. *S. scrofa* may weigh from 50 to 450 kg (Nowak, 1991). In the BBRSP area, *S. scrofa* can be confused only with the collared peccary. Distinguishing characteristics are presented in the account of the latter.

Feral pigs are common in many regions of Texas, including areas along the Rio Grande (Jones and Jones, 1992). In the early 1970s, *S. scrofa* was introduced into BBRSP for sport hunting (Armendariz, pers. comm., 1996). Pigs were not encountered during this study, but one was sighted just outside park boundaries in the Cienega Mountains area, and the species, no doubt, still occurs in the park. As with most other non-native species, free-ranging populations of *S. scrofa* are known to adversely affect elements of the natural environment (Singer, 1981; Wood and Barrett, 1979).

Bos taurus
Domestic Cow

The domestic cow is highly variable in appearance. The body is large and stout with short hair. Coloration and the presence and appearance of horns varies, depending on the breed (Nowak, 1991). In the Texas longhorn, the breed that is maintained at BBRSP, color usually is a combination of browns and white, and both sexes have long, foreword-directed horns. However, cattle of other breeds from neighboring ranches frequently wander on to BBRSP, and these individuals may appear differently. Domestic cows usually have shoulder heights that range from 900 to 1100, and weights between 450 and 1000 kg (Nowak, 1991). It is unlikely that these animals could be confused with any other mammal that occurs on the park.

A herd of approximately 100 longhorn cattle is maintained at BBRSP. They reportedly are restricted to eight pastures within the park, one of which is in the Sauceda area. Four additional areas have been designated as alternative pastures. There is considerable opposition to these cattle from various environmental groups, which insist that the animals are destructive to the ecosystem. Proponents maintain that retaining the cattle will allow the park to preserve the culture of its ranching heritage (Anonymous, 1995*a*).

Capra hircus
Domestic Goat

As with most other domesticated animals, the goat takes on a multitude of appearances. Coloration is highly variable, and horns may be present or absent (Nowak, 1991). If present, horns are flattened from side to side (Ingles, 1965), and may be scimitar-shaped or spiraled, but lack strong transverse ridges (Nowak, 1991). Males possess a prominent beard under the chin (Anderson, 1972). Approximate measurements of *C. hircus* are as follows: total length, 1225 to 1525; tail length, 100 to 150; height, 760 to 1015 (Ingles, 1965). At BBRSP, the domestic goat might be mistaken for the aoudad or ibex. Distinctions are discussed in the accounts of those species.

Feral goats are known from BBRSP but are not common. The skull of a single individual was acquired in a small cave in Lava Canyon. Because these goats are very nimble and can subsist on a variety of foods, they conceivably could be found anywhere in the park. As with other feral mammals, free-ranging goats are very destructive to the natural environment (Nowak, 1991).

Species of Postulated Occurrence

The following accounts pertain to native mammals that, based on their known distributions, may exist in BBRSP but have yet to be documented there. Twenty-seven species of mammals are treated briefly in this section.

Didelphis virginiana
Virginia Opossum

The Virginia opossum is known from Trans-Pecos Texas, but, because of its intolerance of desert habitats, is rare in the region (Schmidly, 1977*a*). It favors areas near waterways (McManus, 1974; Gardner, 1982), and therefore, if present at BBRSP, would be restricted to areas along the Rio Grande and other watercourses in the park.

Notiosorex crawfordi
Desert Shrew

The desert shrew is known from scattered locations across the Trans-Pecos (Armstrong and Jones, 1972; Schmidly, 1977*a*). Records exist from Big Bend National Park to the east of BBRSP (Schmidly, 1977*a*), and from near Marfa, Presidio County, to the northwest (Yancey and Jones, 1996). In addition, *N. crawfordi* has been recorded from the nearby Mexican states of Chihuahua (Anderson, 1972) and Coahuila (Baker, 1956). It favors desert scrub habitat (Baker, 1956; Schmidly, 1977*a*), but also may be found in desert grassland (Yancey and Jones, 1996). It is highly probable that this shrew resides in these types of habitats at BBRSP, probably having gone undetected because of the difficulty of collecting shrews by conventional methods (Blair, 1954; Schmidly, 1977*a*; Jones et al., 1988).

Scalopus aquaticus
Eastern Mole

The eastern mole is known from the Trans-Pecos on the basis of a single specimen acquired in 1887 (Schmidly, 1977*a*). It was taken from an unknown site in Presidio County (Allen, 1891), which at that time consisted of modern-day Brewster, Jeff Davis, and Presidio counties (Baker, 1951). Therefore, the specimen could have been taken in any of these three counties. An additional individual of this species is known from the Sierra del Carmen of northern Coahuila (Baker, 1951; Yates and Schmidly, 1977; Schmidly and Yates, 1978). This mole favors soils that allow for easy burrowing and usually is absent from heavy clay or rocky soils (Yates and Pedersen, 1982). If the eastern mole occurs in BBRSP, it would most likely reside in the loose, moist soils along the Rio Grande (Schmidly, 1977*a*).

Leptonycteris nivalis
Mexican Long-nosed Bat

The Mexican long-nosed bat has been recorded in Texas only from Big Bend National Park and the Chinati Mountains (Hensley and Wilkins, 1988; Schmidly, 1991). Because BBRSP is situated geographically between these two sites, one might expect this species to occur there as well. However, these bats prefer mountainous areas of 1500 to 2300 m (Schmidly,

1991), which are less common in BBRSP than Big Bend National Park or the Chinatis. Furthermore, in Texas, *L. nivalis* relies on the nectar and pollen of century plants (*Agave* sp.) as its primary source of food (Schmidly, 1991). These plants are common in the Chisos Mountains of Big Bend National Park and the Chinati Mountains (Powell, 1988), but are scarce in BBRSP. Therefore, it is conceivable that *L. nivalis* is absent from BBRSP due to the lack of suitable resources.

Myotis auriculus
Southwestern Myotis

In the United States, the southwestern myotis is known from Arizona and New Mexico, but has yet to be recorded from Texas (Warner, 1982). Its occurrence also has been documented in Chihuahua and Coahuila, Mexico (Baker, 1956; Anderson, 1972). Because the projected range of this bat approaches the southern border of BBRSP (Warner, 1982), and given its affinity for arid woodlands and desert scrub (Barbour and Davis, 1969), it is included as a possible inhabitant of the park.

Myotis lucifugus
Little Brown Myotis

The little brown myotis is known from Texas on the basis of a single individual from the Trans-Pecos collected near Fort Hancock, Hudspeth County (Findley and Jones, 1967; Schmidly, 1991). Because there are no shortages of buildings, trees, or rock crevices, the preferred roosting structures of *M. lucifugus* (Fenton and Barclay, 1980), it is not unlikely that this species exists in BBRSP.

Myotis volans
Long-legged Myotis

Myotis volans is known from several localities near BBRSP, including the Guadalupe, Davis, Chinati, Chisos, Sierra Vieja (Schmidly, 1991), and Sierra del Carmen ranges (Baker, 1956). This species prefers high, mountainous, open woodlands, characteristic of these surrounding areas, but mostly absent from BBRSP. *M. volans* rarely occurs in arid lowlands (Warner and Czaplewski, 1984) typical of much of BBRSP. It may, however, occur in the park at some of the higher elevations or as a transient during migration.

Lasionycteris noctivagans
Silver-haired Bat

The silver-haired bat has been recorded from the northwest portion of the Trans-Pecos, but is unknown from the Big Bend Region (Schmidly, 1991). This bat typically is considered a forest-dwelling species (Kunz, 1982), which would explain its absence from BBRSP. However, during migration, *L. noctivagans* may be found in more xeric habitats (Schmidly, 1991) and should be regarded as a potential inhabitant of the park at this time.

Lasiurus blossevillii
Western Red Bat

The western red bat has been recorded in Texas from only a single locality in the Sierra Vieja of Presidio County (Genoways and Baker, 1988; Schmidly, 1991). The species often is taken in riparian habitats consisting of cottonwood, oak, and walnut (Findley et al., 1975; Hoffmeister, 1986). Because of the close proximity of BBRSP to the Sierra Vieja and the presence of the above described habitat in the park, *L. blossevillii* eventually may be found in the park.

Lasiurus borealis
Eastern Red Bat

The eastern red bat is a common inhabitant of east Texas, but records are spotty in the Trans-Pecos where it mostly is restricted to mountainous habitats (Schmidly, 1991). It has been taken from the Chisos and Chinati mountains to the east and west of BBRSP, respectively. If *L. borealis* occurs in BBRSP, it probably does so only as a summer migrant, at which time it might be found in riparian woodland (Schmidly, 1991).

Euderma maculatum
Spotted Bat

The spotted bat is known from Texas only from Big Bend National Park (Easterla 1970*a*; 1973; Schmidly, 1991). In this area, *E. maculatum* is thought to roost in cracks and crevices of the walls of deep canyons (Easterla, 1970*a*). The most probable sites in BBRSP at which this species might occur are Colorado Canyon, Chorro Canyon, and Arroyo Segundo.

Nyctinomops femorosaccus
Pocketed Free-tailed Bat

The pocketed free-tailed bat is known from Texas only from Big Bend National Park (Easterla, 1968; Schmidly, 1991). It also is known from across the Rio Grande in Coahuila, Mexico (Easterla, 1970*b*). It appears to favor , desert areas with deep, rocky canyons (Easterla, 1973; Schmidly, 1991). Colorado Canyon, Chorro Canyon, and Arroyo Segundo seem to be the most probable localities where this bat might be discovered in BBRSP.

Sylvilagus floridanus
Eastern Cottontail

In Trans-Pecos Texas, the eastern cottontail has been documented from several localities in the vicinity of BBRSP, including the Davis, Guadalupe, and Chisos Mountains. This species is found in piñon-oak-juniper woodlands at elevations from about 1500 to 2500 m (Schmidly, 1977*a*). As this habitat is lacking from BBRSP, it is unlikely that *S. floridanus* resides in the park. However, because the park is within the overall distribution of the species (Schmidly, 1977*a;* Chapman et al., 1980), the possibility of its presence should not be discounted.

Spermophilus mexicanus
Mexican Ground Squirrel

The Mexican ground squirrel is known from throughout much of the eastern and central Trans-Pecos (Schmidly, 1977*a)*, but BBRSP lies outside its interpolated range (Schmidly, 1977*a*; Young and Jones, 1982). However, because *S. mexicanus* has been recorded from northern Presidio County, and in the Trans-Pecos prefers desert scrub habitats like those found in BBRSP (Schmidly, 1977*a*), this squirrel should be considered a possible resident of the park.

Dipodomys spectabilis
Banner-tailed Kangaroo Rat

The banner-tailed kangaroo rat is well known from western and north-central parts of the Trans-Pecos, but records from the Big Bend area are nonexistent (Schmidly, 1977*a*; Best, 1988). But, given that this kangaroo rat inhabits desert scrub and grassland habitats similar to those present at BBRSP, and that records exist from northern Presidio County (Schmidly, 1977*a*), this species should not be discounted as a possible resident of the park.

Reithrodontomys montanus
Plains Harvest Mouse

The montane harvest mouse is a rare inhabitant of the Trans-Pecos (Schmidly, 1977*a)*. The closest record to BBRSP is one near the northern boundary of Big Bend National Park (Jones et al., 1993). It was taken in scrub habitat identical to that found in areas of BBRSP. *R. montanus* probably occurs in the park, but, because it is uncommon in the area, its presence has yet to be confirmed.

Peromyscus nasutus
Northern Rock Mouse

The northern rock mouse is known from scattered localities in the Trans-Pecos, including the Chinati and Chisos mountains (Schmidly, 1977*a)*. It seems to prefer rocky areas at elevations greater than those that occur in BBRSP (Schmidly, 1977*a*; Genoways et al., 1979). However, because *P. nasutus* has been recorded from such proximate localities, it is included as a possible inhabitant of BBRSP.

Sigmodon fulviventer
Tawny-bellied Cotton Rat

In Texas, the tawny-bellied cotton rat has been recorded only from the Davis Mountains near Fort Davis (Stangl, 1992*a*; 1992*b*). Additional records from near BBRSP exist in northern Chihuahua (Anderson, 1972). The specimens from Texas were taken in dense grass with scattered mesquite and catclaw at an elevation of about 1580 m (Stangl, 1992*b*). In Chihuahua, *S. fulviventer* was acquired from several sites at lower elevations similar to those found in BBRSP (Anderson, 1972).

Rattus norvegicus
Norway Rat

There are no known specimens of the Norway Rat from Trans-Pecos Texas (Schmidly, 1977*a*). This introduced species is presented in this section only on the basis of its close association with humans, and should therefore be considered a possible inhabitant where humans and their dwellings exist (Jackson, 1982).

Rattus rattus
Roof Rat

The black rat has been collected from nearby Alpine in Brewster County, but no doubt occurs in all towns in the Trans-Pecos (Schmidly, 1977*a*). As with the Norway rat, this non-native species is included in this section because of its association with humans.

Mus musculus
House Mouse

The house mouse occurs throughout the Trans-Pecos, and can be found even at isolated human dwellings (Schmidly, 1977*a*). Although not documented, this introduced mouse probably resides at many of the ranches located within BBRSP.

Ondatra zibethicus
Common Muskrat

In Trans-Pecos Texas and Chihuahua, Mexico, the muskrat previously was a common inhabitant along the Rio Grande and its tributaries (Anderson, 1972; Schmidly, 1977*a*). Recent rises in the human population in the area, as well as an increase in levels of water pollution, have led to the demise of *O. zibethicus* in the Trans-Pecos (Schmidly, 1977*a*). It is possible, but not probable, that this species exists along the Rio Grande in BBRSP.

Nasua narica
White-nosed Coati

The white-nosed coati is known from the Trans-Pecos on the basis of a single specimen collected from near Big Bend National Park (Schmidly, 1977*a*). Local residents have reported the occurrence of *N. narica* in BBRSP, but these reports are unsubstantiated. The species prefers woodlands and rocky areas (Davis and Schmidly, 1994), both present in BBRSP, so an occasional individual may wander into the park from Mexico.

Mustela frenata
Long-tailed Weasel

The long-tailed weasel is known from scattered areas across the Trans-Pecos, but is considered rare in the region (Schmidly, 1977*a*). It is known from Big Bend National Park (Schmidly, 1977*a*), and although there are no published accounts from Presidio County, I have examined a specimen from Marfa, Presidio County (SRSU 2452). *M. frenata* is catholic in its habitat requirements (Davis and Schmidly, 1994), and it is probable that the species exists in BBRSP.

Spilogale gracilis
Western Spotted Skunk

In Trans-Pecos Texas, the western spotted skunk is widespread but records are rare. This skunk often is associated with rocky canyons, which are common in BBRSP (Schmidly, 1977*a*). The species may occur in the park, but if so, probably at low numbers.

Mephitis macroura
Hooded Skunk

The hooded skunk is the rarest skunk known from the Trans-Pecos, but has been documented from both Presidio and Brewster counties. It is a lowland species that prefers rocky canyons and densely vegetated watercourses (Schmidly, 1977*a*), both common to BBRSP. It probably occurs in the park in small numbers.

Felis pardalis
Ocelot

The Ocelot is known from the Trans-Pecos on the basis of one specimen acquired in 1903 from a site between Marfa and Terlingua, Brewster County (Bailey, 1905; Schmidly, 1977*a*). This locality is adjacent to what is now BBRSP. *F. pardalis* may be found in a wide variety of habitats (Kitchener, 1991), but appears to prefer rocky situations with dense vegetation (Davis and Schmidly, 1994). As with the white-nosed coati,

there have been unsubstantiated reports of ocelot sightings in BBRSP. Given the habitat preference and the proximity of the historical record, it is conceivable that *F. pardalis* occasionally may make an appearance in BBRSP.

Extirpated Species

This section includes brief accounts on two species of mammals that are known to have occurred during the historical past in what is now BBRSP, but are now absent from the area.

Canis lupus
Gray Wolf

Gray wolves once were common in Trans-Pecos Texas, but resident populations presently are nonexistent. The last verified reports of *C. lupus* in the area date to 1970 (Davis and Schmidly, 1994). However, on rare occasions, individuals may wander into the region from Mexico (Schmidly, 1977*a*; Jones and Jones, 1992). The extinction of *C. lupus* in the Trans-Pecos was due, in part, to a campaign against the wolf because of its depredation on livestock and game animals (Nowak, 1991). The extirpation of bison (*Bos bison*), the wolf's principle food in the region, also contributed its demise (Schmidly, 1977*a*).

Currently, the Mexican wolf (*C. l. baileyi*), the subspecies of gray wolf that occurs to the south of the Trans-Pecos in Mexico (Schmidly, 1977*a*), is under consideration for reintroduction into Big Bend National Park. Because the home range of *C. lupus* is known to be as great as 13,000 km^2 (Mech, 1974), the species undoubtedly would makes its way into BBRSP.

Ovis canadensis
Mountain or Bighorn Sheep

Once widespread in the mountainous areas of the Trans-Pecos, the mountain or bighorn sheep has suffered a fate similar to that of the gray wolf, albeit for different reasons. Extirpation of bighorns from the region primarily was in response to the ascent of the sheep ranching industry. Domestic sheep outcompeted mountain sheep, and fences that accompanied the former prevented the latter from relocating. In addition, diseases transmitted from domestic sheep, as well as overhunting, contributed to the bighorn's decline. The last documented sighting of a native bighorn in the Trans-Pecos was in 1960 (Schmidly, 1977*a*).

Since the extirpation of the mountain sheep in the Trans-Pecos region, the species has been reintroduced into several areas within the region (Davis and Schmidly, 1994). The reintroduction of 20 individuals into the Madera Canyon area of BBRSP is scheduled for the fall of 1997.

CONCLUSIONS AND RECOMMENDATIONS

With data obtained during two years of extensive field work supplemented by examination of museum specimens and a thorough review of the literature, several questions regarding the mammalian fauna of BBRSP were answered. Fifty-nine species of native mammals were verified to occur within the boundaries of BBRSP. In addition, two nondomestic introduced species and seven domestic species were documented to inhabit the park. There are 27 additional species that, based on their overall distribution, have a reasonable chance of occurring in the park.

In addition to determining the number and kinds of species of mammals in the park, considerable data regarding the distribution and ecology of the mammals of BBRSP were acquired during the study. This information undoubtedly will be vital to Texas Parks and Wildlife personnel when considering the management of the BBRSP ecosystem. The following is a list of five common objectives of ecosystem management (Grumbine, 1994), with recommendations that apply to mammals for achieving these goals in BBRSP:

1. Sustain viable populations for each native species that occurs in the area.—The first action to achieve this goal is to continue collecting data on mammals in BBRSP. Efforts should focus on acquiring additional data on the diversity and distribution of mammals, as well as on long-term monitoring programs aimed at obtaining temporal data on the status of mammal populations, especially those of species that were under-represented in this study, such as *Thomomys bottae*, *Sigmodon ochrognathus*, *Neotoma mexicana*, and several species of bats.

In addition to adding to our knowledge of the distribution and ecology of mammals known to occur in BBRSP, continued sampling probably will result in the addition of new mammals to the current species list. Special effort should be made to determine if any species listed as threatened or endangered occur in the park. The most likely candidates that fit this description are *Leptonycteris nivalis* (state and federal endangered), *Euderma maculatum* (state threatened), *Nasua narica* (state threatened), and *Felis pardalis* (state and federal endangered).

From each mammal specimen collected at BBRSP in the future, I recommend the collection of tissue samples consisting of skeletal muscle, liver, heart, kidney, spleen, lung, and brain. These materials, if archived in a suitable cryogenic facility, have the potential for serving as an important source of data for future research in conservation biology, molecular systematics, and public health issues (Baker, 1994) regarding the mammals of BBRSP. The curators and collections manager at the Natural Science Research Laboratory at the Museum of Texas Tech University have agreed to house and archive any such materials acquired from BBRSP.

In addition to widespread sampling, long-term monitoring of sensitive areas is recommended. This research should focus on trends in mammal populations, especially those due to changes in the condition of the environment (e.g., what are the effects of sustained drought on mammal populations at BBRSP?). I suggest periodic sampling of Arroyo Segundo, the Cienega area, the Solitario (near Tres Papalotes), the Las Quevas area, creek drainages near Sauceda, and the Los Alamos area (at the South Fork of Alamo de Cesario Creek).

Data acquired during these long-term monitoring programs should be maintained in the GIS system at TPWD headquarters. With this system, spatial and temporal data on mammals can be integrated with information regarding other taxa of animals, management decisions, land use, hydrology, physiography, and geology, as well as vegetation, water quality, pollution, and other aspects of the environment as they becomes available (Johnston et al., 1994; D'Erchia, 1995). Examination of mammal data with respect to these attributes can then be provided to resource managers as a guide to making effective management decisions that will allow for the maintenance of viable populations of the native mammals of BBRSP.

In the strict sense, achieving the goal of maintaining viable populations of all native species of mammals would require the re-introduction of extirpated species. This action has received much consideration, especially regarding the Mexican wolf and the bighorn sheep. However, because the areas adjacent to BBRSP primarily are used for livestock ranching, there is con-

siderable objection and political pressure against the reintroduction of a large predator, such as the Mexican wolf. Therefore, this mammal probably will not become part of the BBRSP fauna in the near future. On the other hand, there currently are plans for the re-introduction of the bighorn sheep into BBRSP. In the fall of 1997, 20 Bighorns from Arizona reportedly are to be transplanted into the Madera Canyon area (Anonymous, 1995*c*). In preparation for the arrival of the bighorns, an attempt should be made to eradicate the non-native aoudad from the park. It is speculated that should these two bovids occur sympatrically, they would compete for similar resources, probably to the disadvantage of the bighorn (Gray and Simpson, 1980; Nowak, 1991).

2. Provide protected areas that consist of all native habitat types.—Two areas within BBRSP seem quite appropriate with regard to this objective. The most ideal location is the Cienega Mountains region. This area consists of variable topography with a considerable amount of desert scrub and desert grassland, and, with Cienega Creek running through the area, stretches of riparian habitat several km in length. Also, one of the few stands of juniper woodland in the park occurs on the southern slope of Cienega Mountain. Furthermore, this region is especially important in terms of mammalian diversity and is inaccessible to the public.

The other site I suggest for special consideration is the Los Alamos Ranch area including the northeast rim of the Solitario. In addition to the abundance of desert grassland and scrub in the area, the South Fork of Alamo de Cesario Creek provides a unique riparian area dominated by willow, walnut, and oak. Moreover, there are scattered stands of juniper woodland in the area. This area supports a substantial population of ghost-faced bats, a species considered rare elsewhere in the United States.

Setting aside these sites as regulated protected areas will allow for managing biodiversity with what Grumbine (1994:29) termed a "systems perspective." Management using this philosophy focuses on all hierarchical levels of biodiversity, not simply individual species, populations, or habitats.

3. Preserve natural ecological and evolutionary processes.—This includes the maintenance of disturbance regimes, such as natural fire and floods, and the retention of natural hydrologic features of the park. It also includes preserving interspecific relationships between native species, and prevents interactions between native and introduced species. This would require the re-introduction of extirpated native species as well as the removal of exotics. These topics were covered above in the discussion of goal number one.

4. Design long-term management programs.—Programs for the management of the BBRSP ecosystem should be designed to last long enough to allow evolutionary processes to function. Much of BBRSP has been disturbed by over 100 years of extensive grazing, and management plans for the recovery of the ecosystem will require several years to reverse the effect. The indices of diversity and species composition presented in this document can serve as baseline data when assessing the effectiveness of restoration efforts (Hall and Willig, 1994). Levels of diversity often can be used to appraise environmental disturbances (Margules and Usher, 1981), and fluctuations in species composition can serve as an indicator that the ecosystem is under stress (Lovell et al., 1985). Long-term management policies should be flexible, allowing for new scientific data, changes in the unpredictable environment, and alterations in park conditions.

5. Accommodate visitor use.—This should be attempted with as little impact on the environment as possible. Access to environmentally sensitive areas, such as those mentioned under goal number one and two, should be limited Unfortunately, and not by coincidence, many of these areas are popular with park visitors. And as park visitation undoubtedly will increase in the future, so will its negative impact on these areas. However, complete prohibition of access to these places is unreasonable, as many of them are what attracts visitors to the park. A solution is to provide limited access to sensitive areas, possibly through small guided tours.

Visitor safety regarding mammals is yet another concern. Many people fear mammals because of the diseases they are known to transmit. During 1994, 177 mammals were tested for rabies, and all were negative. But, because this disease occurs in cyclic epidemics, especially in certain bats in the area (Jimenez Guzman, 1982), I suggest continued monitoring of bats and carnivores in areas of heavy visitor usage. Also, a survey of the incidence of hantavirus and plague among ro-

dents would provide valuable information for park management.

Another issue involving park visitors centers on the presence of the longhorn cattle herd within the park. Proponents of the longhorns claim that they attract visitors to the park and that they are beneficial to the environment, whereas opponents maintain that they are an "eyesore" and are destructive to the environment. Interestingly, there are no data from BBRSP that I know of that support either view. I suggest each visitor be given a questionnaire asking their opinion on the cattle. Did they really come to see the longhorns? Also, there should be a scientific study conducted to determine the effects of the cattle on the BBRSP ecosystem.

As visitor use increases, so should interpretive programs and exhibits, especially on the lesser known mammals such as bats and rodents. Many patrons visit parks to acquire knowledge about the natural history of the area. To be informed of the diversity of mammals at BBRSP, as well as the unique natural history of many of them, certainly would increase the quality of their stay.

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APPPENDIX I.
DATABASE FOR ENTRY OF FIELD DATA

The database below was used for field entry of data on mammals collected at Big Bend Ranch State Park during 1994 and 1995. The database was constructed using Microsoft Excel version 3.0 for Macintosh computers. A description of the 31 fields that comprise the database follows.

SPEC NO	COLL	CAT NO	TK NO	TTU NO	ORDER	FAMILY	GENUS
SPECIES	SEX	TL	TV	HF	EAR	WT	REPRO
PELAGE	PARA	DAY	MO	YR	CO	QUAD	EASTING
NORTHING	SITE	HABITAT	ASSOC VEG	SUBSTRATE	TOPO	NOTES	

Explanation of fields:

SPEC NO-Refers to specimen number assigned to mammals at BBRSP.

COLL-Initials of collector/cataloger.

CAT NO-Catalog number of preparator.

TK NO-TK number (number applied to frozen tissue) of specimen.

TTU NO-Museum catalog number of specimen.

ORDER/FAMILY/GENUS/SPECIES/SEX-Self explanatory.

TL/TV/HF/EAR-Standard external measurements of specimen in mm. TL=total length, TV=tail vertebrae, HF=hind foot, Ear=ear.

WT-Weight of specimen in grams.

REPRO-Reproductive data taken from specimen.

PELAGE-Coded description of pelage condition of specimen. A=adult, AM=adult with seasonal molt, SA=subadult J=juvenile.

PARA-Notes on ecto/endo-parasites observed on or collected from specimen.

DAY/MO/YR-Day, month, and year specimen was collected.

CO-County from which specimen was collected. For this study, the first letter of either county (Presidio, Brewster) was used as an abbreviation.

QUAD-Coded reference for USGS quad within which locality of specimen lies.

EASTING-Distance of locality, in meters, east of a point 500,000 m west of the center of UTM zone 13.

NORTHING-Distance of locality, in meters, north of the Equator.

SITE-Numerical reference to traplines/nets from which specimen was taken.

HABITAT-Coded general description of habitat from which specimen was taken. DG=desert grassland, DS=desert scrub, J=juniper woodland, R=riparian.

ASSOC VEG-specific types of plants (in order of dominance) in area from which specimen was taken.

SUBSTRATE-General description of substrate in area from which specimen was taken.

TOPO-Coded general description of the topography from which specimen was taken. L=lowland, U=upland, C=canyon.

NOTES-Field to add any additional information about a specimen that is not appropriate for other fields.

APPENDIX II.
GAZETTEER OF LOCALITIES SAMPLED

All localities are based on UTM coordinates taken in zone 13. Symbols for methods of collection used at various localities are as follows: A=mist nets, B=Sherman traps, C=Museum Special traps, D=Victor rat traps, E=gopher traps, F=Conibear traps, G=Havahart traps, H=leghold traps, I=firearms, J=hand-capture, K=salvaged.

UTM Coordinates		Method of Collection										
Easting	Northing	A	B	C	D	E	F	G	H	I	J	K
573986	3270053		X									
575323	3292088		X									
576060	3288074	X										
576206	3268568		X									
576311	3271128		X									
576390	3296223		X									
576550	3295203						X					
576564	3295022	X	X									
576591	3295069	X										
576609	3295115	X										
576628	3294971	X										
576646	3296118		X									
576658	3296469	X					X					
576674	3295147	X										
576699	3296276	X	X				X	X				
576699	3296292	X										
576708	3296384	X	X				X	X	X			
576712	3296232	X										
576721	3296287		X									
576730	3296319	X										
576730	3295308									X		
576757	3296109		X									
576760	3295806		X									
576773	3295277		X									
576777	3296362	X										
576783	3296292	X								X		
576783	3296202							X	X			
576785	3296105		X				X					
576788	3296184	X										
576790	3296211		X				X					
576795	3296125	X										
576796	3295418		X							X		
576799	3296134									X		
576804	3296151		X									
576805	3296248	X					X					
576808	3295784		X									
576808	3296211									X		
576823	3296177	X								X		
576830	3296165							X				
576836	3296251	X	X	X	X					X		
576837	3296137	X										
576839	3296085									X		
576842	3296279	X	X							X	X	
576844	3296174	X	X									
576844	3296251	X										
576846	3296245		X	X								

Appendix II. (continued).

UTM Coordinates		Method of Collection										
Easting	Northing	A	B	C	D	E	F	G	H	I	J	K
576855	3295469									X		
576866	3295865									X		
576872	3295728									X		
576931	3296613		X									
576947	3295987		X									
576969	3296359		X									
576970	3296222		X									
576985	3295102		X									
577000	3287710	X										
577002	3296360		X									
577050	3287705	X										
577066	3296038		X									
577099	3296389		X									
577106	3291796		X									
577120	3295040		X									
577120	3295100		X									
577192	3295041		X									
577321	3287548		X			X	X		X			
577436	3293201		X									
577472	3287353		X			X						
577526	3287386		X									
577553	3287272	X										
577563	3287242	X								X		
577570	3287269	X										
577589	3287154	X	X									X
577690	3290260		X									
577797	3287037	X										
578146	3288978		X									
578150	3286073	X	X									
578883	3292424		X									
579237	3292359		X									
579410	3289121		X									
579592	3269404									X		
579607	3269545	X										
579684	3269447		X									
579859	3292474		X									
579888	3269478									X		
580095	3264240	X										
580196	3264339	X										
580238	3264348	X										
580320	3264432	X										
580327	3264457	X										
580342	3288931	X	X									
580522	3264400											X
580916	3264339	X										
581230	3264998		X									
581288	3268847		X									
581659	3279903		X									
582110	3288790		X									
582656	3265713			X								
582900	3268000									X		
582906	3266716		X									
583096	3272189		X									
583205	3282984		X									

Appendix II. (continued).

UTM Coordinates		Method of Collection										
Easting	Northing	A	B	C	D	E	F	G	H	I	J	K
583788	3266885		X									
583846	3290112		X									
584021	3269813		X									
584337	3269447									X		
584531	3266930		X									
584964	3273523		X									
585434	3286791		X									
586777	3249651		X									
586809	3262961		X									
586843	3262914	X										
586886	3265832		X									
586907	3262929	X										
586937	3262923	X	X				X	X		X		
586938	3262910	X										
586973	3262923	X										
586978	3262992		X									
586983	3262860	X										
586983	3262869	X										
587062	3262884					X						
587137	3262985					X						
587184	3262927		X									
587250	3262918	X	X									
587250	3262981		X									
587263	3263005	X										
587281	3262891									X		
587302	3262817		X									
587448	3262943	X										
587490	3262902	X										X
587570	3249037											X
587667	3266036											
588746	3247263		X									
589301	3246448	X										
589319	3246461	X										
589348	3246503		X	X								
589354	3246455	X										
589699	3262276		X									
589824	3265632		X									
590260	3264372	X										
590643	3262195		X									
590668	3261956									X		
590728	3245948		X									
590980	3262597	X	X									
591022	3261963									X		
591202	3262771	X										
591209	3262798	X										
591851	3245491		X									
592496	3244969		X									
592858	3262597		X									
592898	3261518				X							
592955	3259156	X										
593789	3264731	X										
593790	3264766	X										
593918	3264842	X										
595150	3252057	X	X									

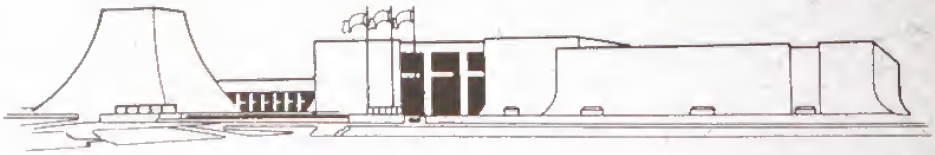
Appendix II. (continued).

UTM Coordinates		Method of Collection										
Easting	Northing	A	B	C	D	E	F	G	H	I	J	K
595478	3262749	X	X									
595848	3258744		X					X				
596232	3258492	X	X									
596255	3262051		X									
596699	3259093		X					X				
596963	3264505											X
597319	3251802		X									
597424	3260494		X	X								
597543	3261182		X									
597663	3252298											X
598044	3263850	X										
598124	3263864	X										
598125	3260852		X									
598198	3260782									X		
598236	3263889	X										
598326	3263912	X										
598459	3260646		X									
599495	3261227		X									
599506	3259765		X									
599525	3261240									X		
599556	3259992	X										
599607	3261323		X									
599751	3261864		X									
599794	3261524	X										
599811	3261545	X										
599957	3261615	X										
599992	3265848		X									
600515	3252408		X									
600518	3256679		X									
600634	3263701		X									
600665	3259720	X										
600684	3259365		X					X				
600689	3259514	X										
600694	3259751		X									
600786	3260060		X									
600868	3256344		X									
600914	3260458		X									
601031	3260217		X									
601059	3260130		X									
601105	3260471					X						
601154	3260197		X									
601203	3260197									X		X
601221	3260400		X									
601273	3260059		X									
601325	3260789	X					X	X				
601335	3260787	X	X									
601452	3260625			X								
601508	3260673		X									
601560	3260590		X									
601605	3241136	X										
601619	3260741		X									
601622	3260685		X									
601632	3241210	X										
601973	3253265		X									

Appendix II. (continued).

UTM Coordinates		Method of Collection										
Easting	Northing	A	B	C	D	E	F	G	H	I	J	K
602053	3260740											X
602211	3256243		X	X				X				
602357	3260937				X							
602473	3260516									X		
602487	3241236		X									
602506	3260843			X								X
602666	3260640		X									
603101	3263765											X
603273	3263098				X							
603790	3260448									X		
603960	3241085		X									
604886	3240689	X	X				X					
605201	3260431		X									
605576	3257735		X									
605667	3261229		X									
605746	3261330		X									
605774	3261181		X									
605895	3261011									X		
606085	3259112		X									
606207	3256765		X									
607243	3255556	X										
607355	3255359	X	X									
607610	3263630									X		
608255	3239563	X	X									
608309	3239482		X							X		
608427	3250324	X										
608437	3253203	X										
608477	3253180	X										
608597	3253243	X										
608608	3253227	X										
608629	3262171		X									
608642	3253280	X										
608747	3264582		X									
608776	3253333	X										
608870	3253520	X										
608955	3253483	X										
609027	3253496	X										
609289	3253592	X										
609394	3249918	X										
609405	3261495		X									
609522	3249929	X										
609585	3249854	X										
609611	3260698		X									
609770	3253645		X									
609772	3249673	X										
611283	3249529	X										
611393	3249399	X	X									
612120	3267800											X
612321	3268161		X									
612594	3268946			X	X							
612683	3265440		X									
613639	3265303		X									
614094	3266037		X									
614303	3264882									X		

Appendix II. (continued).

UTM Coordinates		Method of Collection										
Easting	Northing	A	B	C	D	E	F	G	H	I	J	K
614350	3268071		X									
614360	3268395	X										
614458	3265716		X									
614618	3266110			X	X							X
614672	3246532										X	
614933	3267912		X									X
614933	3246380										X	
614935	3268144		X					X				
615033	3263895		X									
615063	3261184		X									
615371	3261358		X		X							
615404	3268775	X					X	X				
615409	3268594		X									
615458	3268807	X										
615504	3263238		X									
615515	3268870	X										
615525	3268958	X	X									
615559	3268762	X	X							X		
615565	3268878	X										
615599	3268863	X										X
615650	3268869	X										
615747	3255837		X									
615786	3263185				X							
615800	3238476		X									
615947	3262894									X		
615951	3263099		X					X				
616012	3263115		X									
616984	3256548		X									
617223	3256581		X					X				
617281	3261484		X									
617505	3256674		X									
617542	3237777		X									
618185	3257611		X	X		X		X				
618322	3258007		X					X				
619081	3260561		X									
619125	3258986		X									
619408	3260416		X									
620694	3240946		X									
620726	3238321					X						
620927	3238664		X									
621243	3239655		X									

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